SIGNALS

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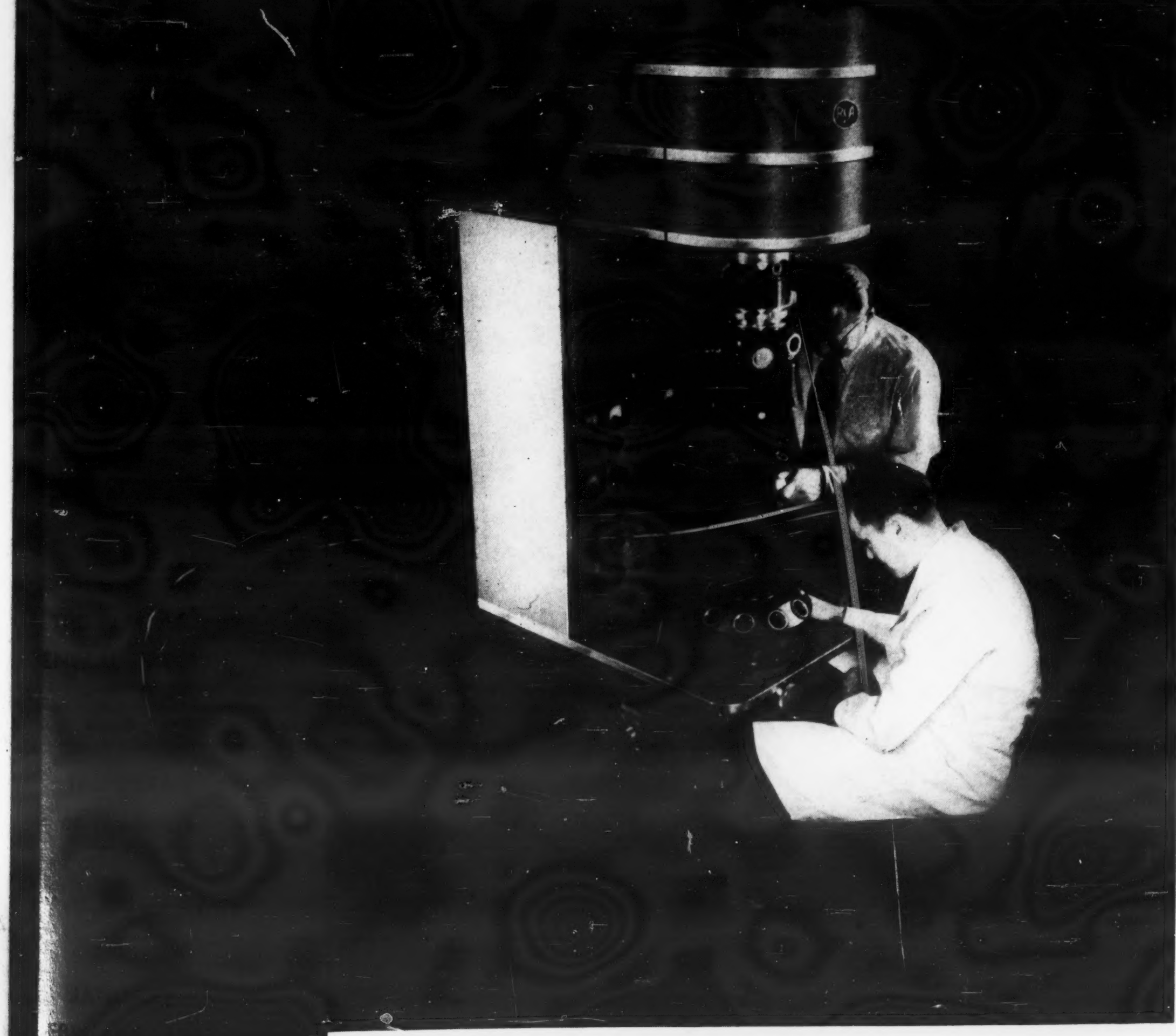

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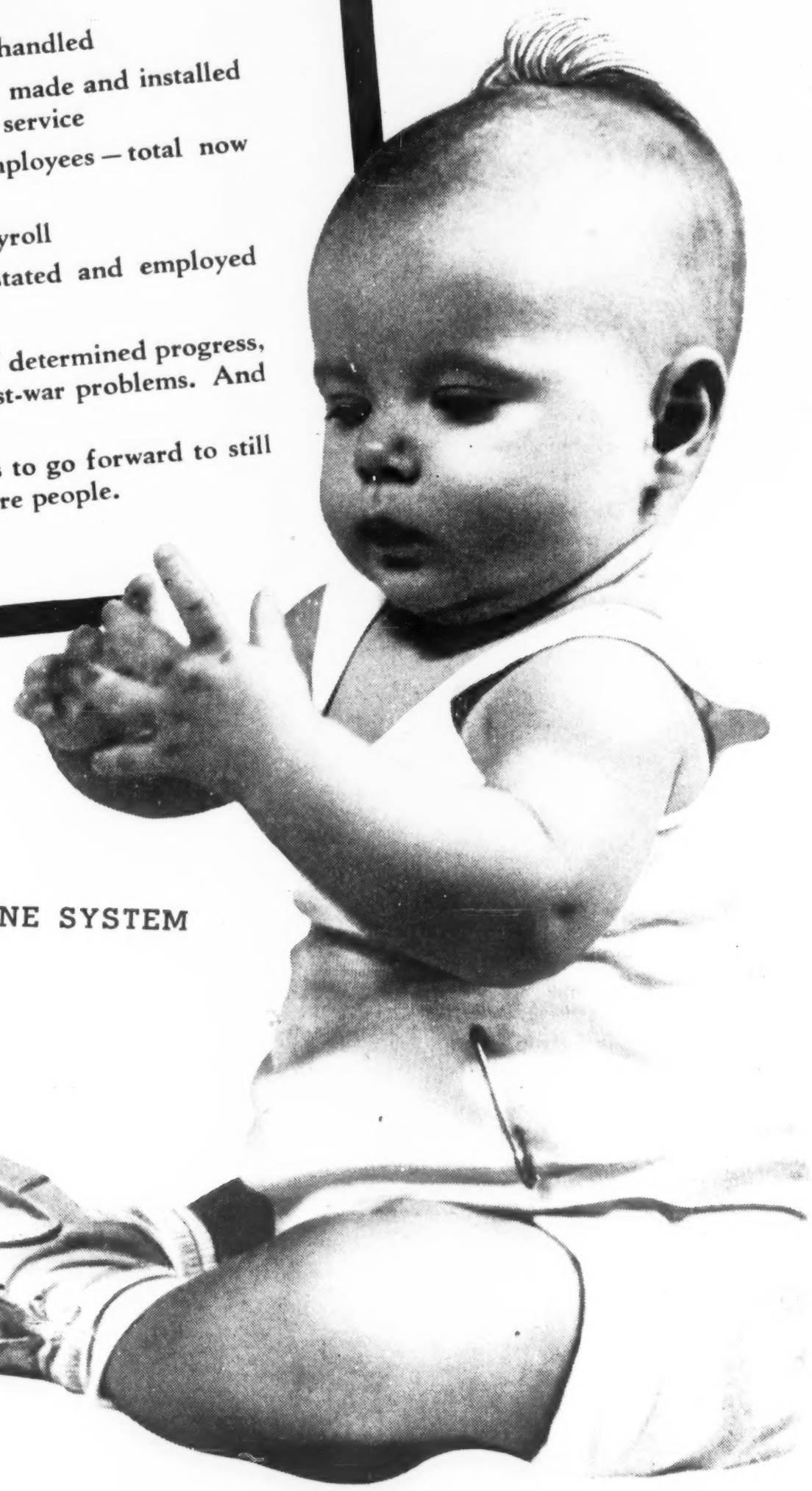
The story of the year was one of determined progress, despite shortages and many post-war problems. And most calls went through fast.

For 1947, the Bell System aims to go forward to still better service for more and more people.



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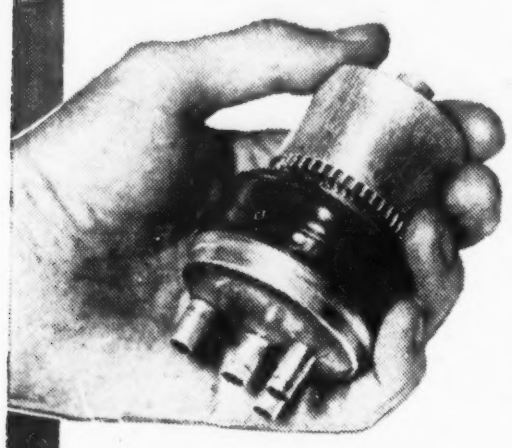
NOW THE 4X500A POWER TETRODE

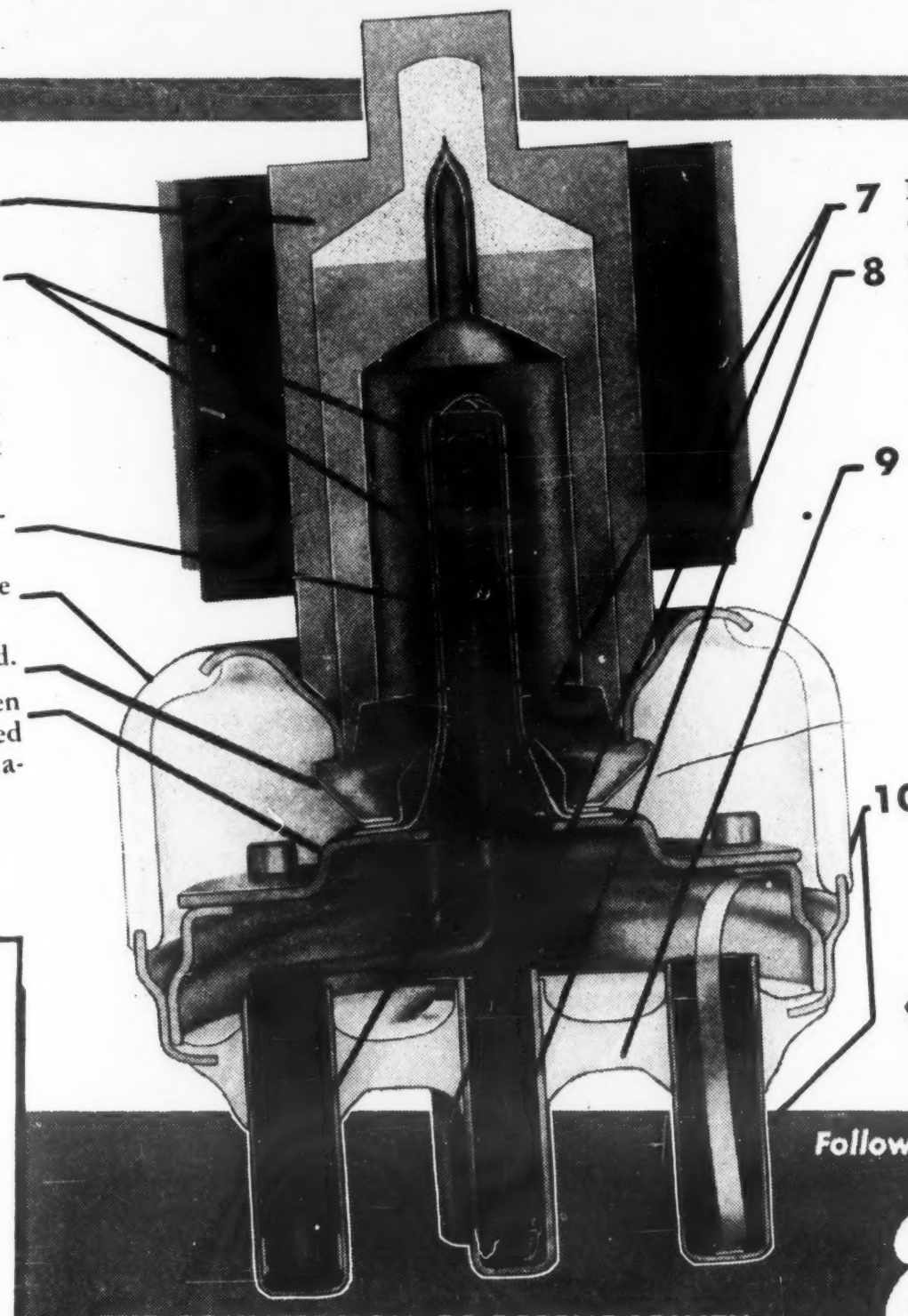
Now, with the new 4X500A, the advantages of the Eimac-designed tetrode are brought to the 500-watt class.

The 4X500A includes the outstanding VHF performance, stability, ruggedness, and freedom from undesirable primary and secondary grid emission that have made the Eimac 4-125A and 4-250A the obvious choice of transmitter engineers for important sockets in both low-frequency and VHF applications.



Here is a transmitter-man's tube intended to make life more simple for the transmitter engineer. The 4X500A is designed for functional application; note the nearly perfect shielding between grid and plate circuits made possible by the low-inductance screen mounting disc which terminates in a contact ring on the envelope. The large low-inductance tubular control-grid lead within the envelope terminates at the center of the base. This design makes it easy to build coaxial tank circuits around the 4X500A. These are only two of its many features. Among others are the rugged 500-watt air-cooled anode, Eimac-processed grids, and silver-plated terminals pointed out below.

It isn't necessary to design your transmitter around promises. Eimac 4X500A tetrodes are available NOW. They'll deliver as much as 1750 watts useful output at 110 Mc. with but 25 watts driving power (two tubes). They'll deliver 3500 watts at the same frequency with 50 watts driving power (four tubes, push-pull-parallel). Complete operating information and ratings are in the technical data sheet for the 4X500A—now available on request.



1 External Anode, 500 watts dissipation, forced air cooled.

2 Control and screen grids precisely aligned—assures maximum plate efficiency and low control and screen grid currents. (Primary and secondary grid emission is positively controlled by exclusive Eimac grid processing.)

3 Double spiral filament—rugged, stable emission.

4 Hard glass envelope—ample r-f insulation.

5 Electron bombardment shield.

6 Rigid, low-inductance screen grid mount assures improved VHF operation and permanent alignment.

7 Filament terminals—heavy duty, large contact areas.

8 Control grid terminal—low inductance, logically placed for maximum isolation between input and output circuits. Centered for use in coaxial cavities.

9 Molded glass base—maintains precise alignment of all terminals for ease and simplicity of insertion in sockets. Makes possible compact design, and low inductance lead engineering. (All base terminals plus concentric screen grid terminals are silver plated for minimum r-f resistance.)

10 Concentric ring and pin type screen grid terminals for VHF and cavity circuits or pin sockets.

CROSS SECTION EIMAC 4X500A POWER TETRODE

ELECTRICAL CHARACTERISTICS

4X500A POWER TETRODE

Filament: Thoriated Tungsten
Voltage . . 5.0 volts
Current . . 13.5 amperes

Direct Interelectrode Capacitances (Average)
Grid-Plate . 0.05 *uufd*
Input . . . . 12.8 *uufd*
Output . . . 5.7 *uufd*

Maximum D-C Plate Voltage . 4000 volts

Maximum D-C Plate Current . 350 ma.

Maximum Plate Dissipation . . 500 watts

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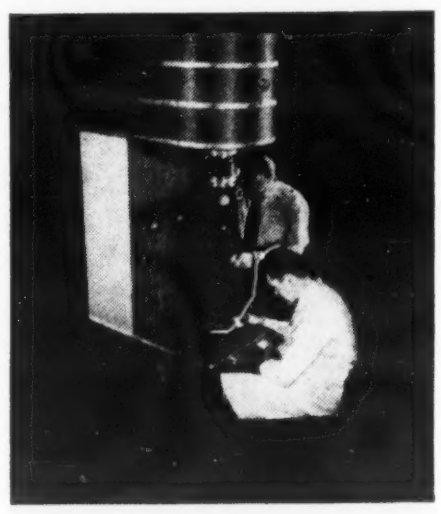

The Cover

RCA's electronic microscope has a magnification power of 180,000 diameters, will open up an entirely new world for the scientist.

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This Issue

Industrial participation in the war effort is the subject of this issue of SIGNALS.

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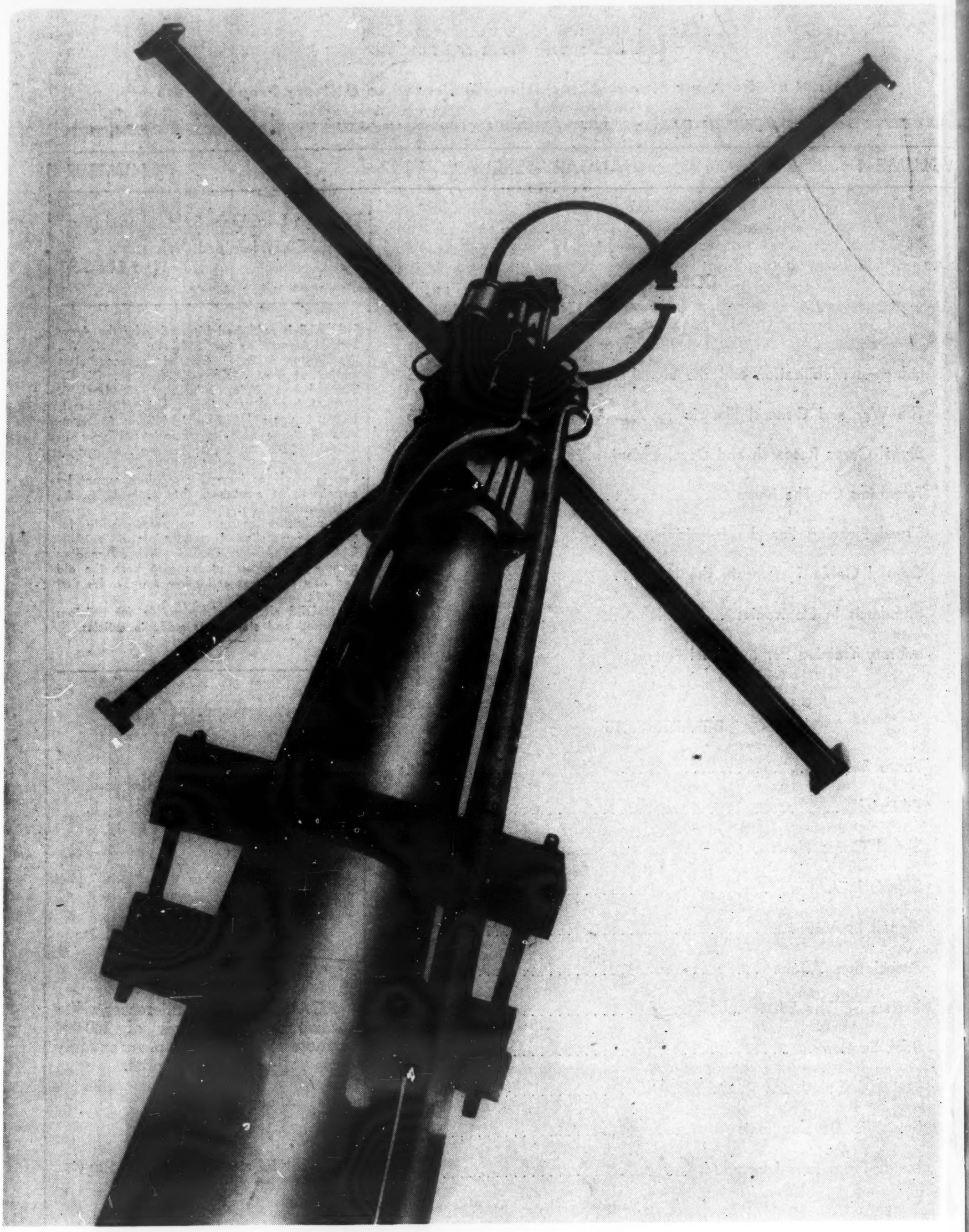


The radiator for DuMont's television station, WABD, New York.

INDUSTRIAL MOBILIZATION AND THE SIGNAL CORPS

By Brig. General C. H. Arnold

Chief, Procurement and Distribution Service Office of Chief Signal Officer

SIX AND one-half billion dollars worth of Signal Corps equipment was procured by the Army during the recent war. This fantastic stock-pile of electronic, communication and photographic materiel represented a 1500-fold increase over peacetime procurement and climaxed two decades of planning for such an emergency as was touched off by Jap bombers over Pearl Harbor.

Shortly after World War I, for the first time in the history of the nation, an organization was formed within the military establishment which was designed to plan in advance for the procurement of supplies and the effective utilization of our national resources in time of war. It had been recognized for many years that such planning was an essential complement to the mobilization of manpower, but the need had not been considered sufficiently urgent to warrant legislative action. However, realization of the detrimental effects of the chaotic, uncoordinated and wasteful procurement activities of the first general war on the national economy, and on the prosecution of the war itself, quickly led to enactment of the enabling legislation required for the inauguration of a comprehensive planning program.

The Chief Signal Officer's planning group, throughout the years following its establishment, consisted of a mere handful of officers and clerks. Although the scope of their activities progressively widened, paced by the growing radio and electronics industry, lack of funds precluded enlargement of the group, or the employment of personnel qualified by industrial experience for the many technical phases of the work. Many manufacturers were reluctant, even unwilling, to divert attention from normal operations to participate in planning for a "purely imaginary war," a further serious deterrent to intelligent, realistic planning. Some few forward-looking industrialists did, however, contribute their time, knowledge and experience in support of the military efforts, thus materially aiding the formulation of a wartime industrial mobilization program.

The Halcyon Years

The rapidity of development in communications and electronics, coupled with limitations in appropriated funds, made it all but impossible to parallel the state of the art. Above all, the plans did not meet the need which arose, simply because of human inability to foresee the nature of future events.

Actual World War II procurement of equipment exceeded in scope and volume any predictable supply objective. This failure can be easily understood when we realize that Signal Corps expenditures for the 19-month duration of World War I totalled about $130,000,000, as compared with a World War II outlay, for a comparable period, in excess of $3,500,000,000.

Brig. Gen. C. H. Arnold heads the Signal Corps Procurement agency.

Despite the inadequacy of the detailed program, the planning years were well spent. Procedures and techniques for computing requirements had been perfected, and the nucleus of a skilled organization had been established. Many sources of supply for communications and electronic equipment had been explored. Interchange of information between the Signal Corps and manufacturers had resulted in a mutual comprehension of many of the problems of each. Possible shortages in components and materials had been revealed. Many Signal Corps items had been cleared with industry for practicability from a mass production standpoint. Potential capacity for certain critical items had been developed through "Educational Orders." Finally, general thinking on matters of emergency military supply was greatly advanced.

Acceleration

Between 1939 and Pearl Harbor, due to the state of "limited emergency" which existed, the planning program was accelerated. The nuclear unit underwent a moderate expansion and, for the first time, production engineers were provided to assist in the program. Industrial effort began to include problems of military supply, and the effects of foreign orders on the nation's productive capacity became apparent. The Defense Plant Corporation was established under the Reconstruction Finance Corporation to provide Government financial assistance in the mobilization of industry. The Tax Amortization Law was enacted, paving the way for private expansion. Legislative action re-

moved restrictions on contract negotiation. The Office of Production Management, later the War Production Board, was formed. Priorities system was inaugurated and the Office of the Under Secretary of War was created to supervise the procurement of all military supplies for the War Department.

The Signal Corps devoted increasing attention to component and material supply, and some expansion was initiated—for aircraft communications and navigational aids, for steatite, for wire W-130, and for transmitting and special purpose vacuum tubes.

CSO Procurement

The Chief Signal Officer's wartime duties included procurement of the following major items of equipment and supplies: "radio direction and range finding (radar); telephone; cable; telegraph; teletype; facsimile equipment; signal communication for aircraft; fixed airways systems; air navigational aids; communications equipment for motorized armored forces and other ground troops; including parachute troops; sound recording and interception; meteorological; photographic, V-mail; fixed sea coast defense and command; fire control; pigeon equipment; cryptographic, coding and cipher equipment, including secret inks and associated chemicals; and experimental, research and special types of Signal Corps equipment."

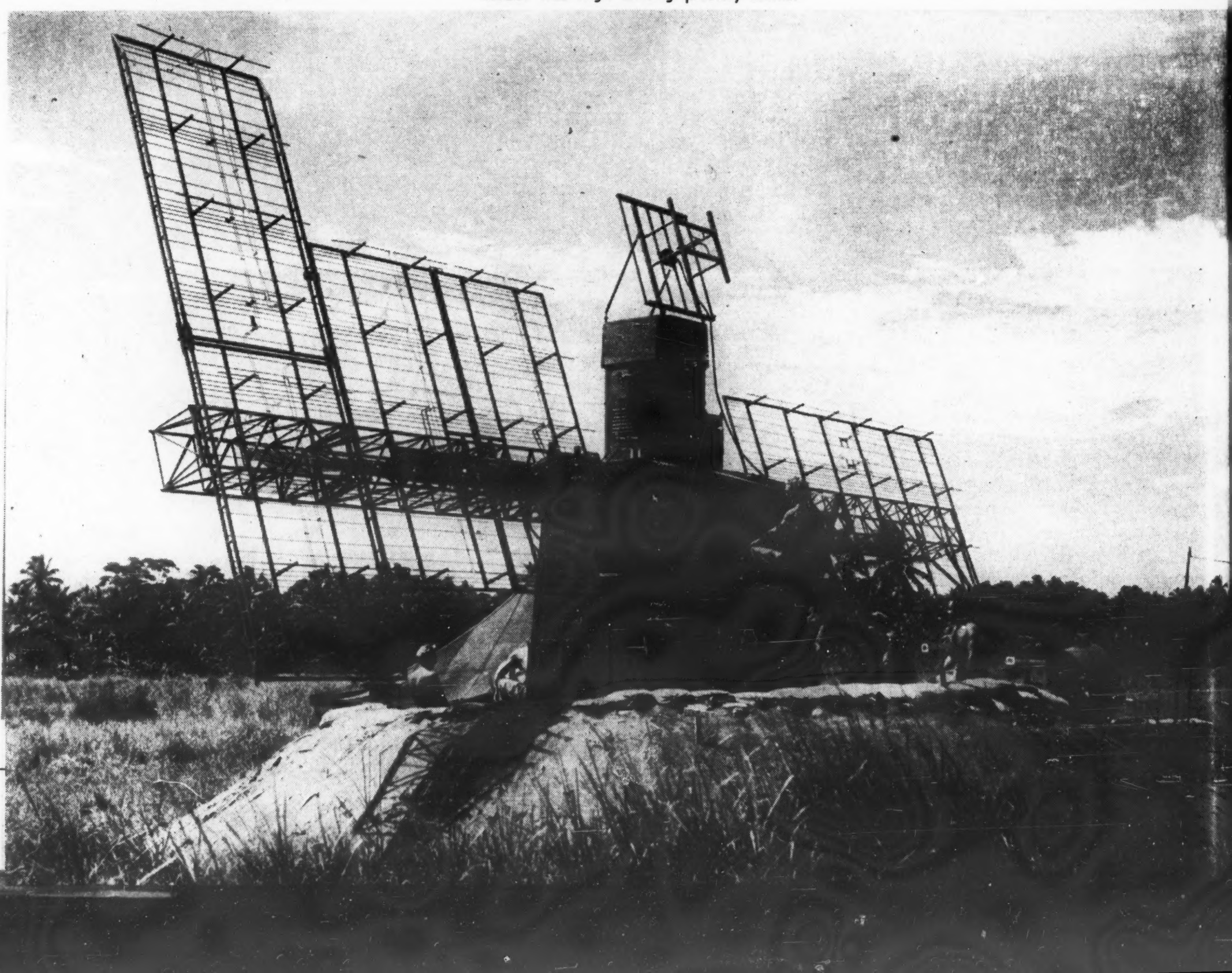
The procurement mission was many-phased, including the following responsibilities: computation of requirements for end items, component parts and materials, including compilation of requirements of the United Nations for signal equipment and supplies; supervision of all matters concerning production of signal equipment, including investigation of productive capacities, expansion and conversion of facilities, distribution of orders and maintenance of production lines; expediting of production, components, materials, and machine tools and production equipment; processing of all priorities matters; all contracting matters and policies, including initiation and supervision of procurement for allied requirements; price adjustment, cost analysis, renegotiation, and contract termination; inspection and acceptance of equipment; supervision over accountability for Government-furnished facilities; Government-furnished equipment, and Government-loaned equipment; disposition and redistribution of idle and excess production facilities; and materiel demobilization.

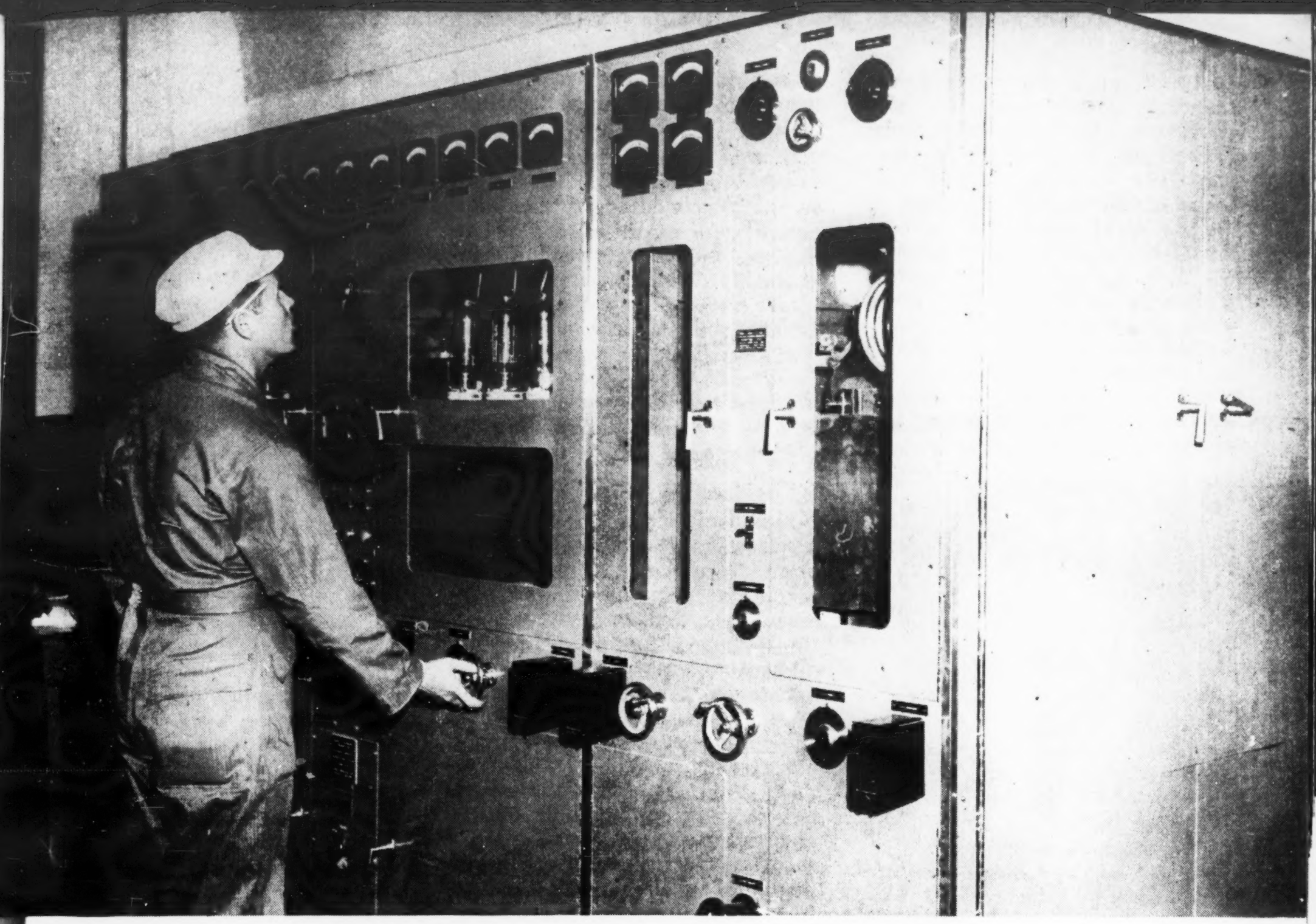
After Pearl Harbor

Immediately following Pearl Harbor, planning and current procurement activities of the Signal Corps were merged to form the wartime procurement organization. In peacetime, there were about 167 persons, in both Washington and field offices, performing all procurement planning, purchasing, expediting, and inspection functions. At peak strength, in 1944, about 4,500 persons were engaged in planning and purchasing, while over 6,200 others were occupied in inspection alone.

Actual operations were to a great extent performed in the field offices under the supervision of the Washington group. In

Radar was high among priority items.





Standardized electronic equipment covers all communications components.

peacetime there were three districts, located at New York, Chicago, and San Francisco. After the war began the districts were gradually shifted about in order to effect better geographical distribution of the procurement load, and by the end of 1942 the three districts were installed at Philadelphia, Dayton, and Fort Monmouth, New Jersey.

In general, each district specialized in the procurement of certain types of equipment. The Monmouth District, adjacent to and in continuing contact with the Signal Corps Engineering Laboratories, procured the research and development items, placed all development contracts and handled all radar and newly developed ground equipment. The Dayton District concentrated on airborne items and development equipment peculiar to the Air Forces, being readily accessible to the Air Forces installation at Wright Field. Philadelphia supplied the great bulk of standard and component items. This plan of organization was retained throughout most of the war years.

The procurement cycle begins with a determination of troop requirements in supplies and equipment, a necessarily complex process, further complicated during wartime by numerous unpredictable variables. If procurement needs could be determined at the beginning of a war, the task would be half accomplished. This, unfortunately, is not possible.

It is frequently said that the Services did not know what they wanted and consequently industry could not prepare in advance to meet procurement needs. Certainly items became obsolete overnight with concurrent unprecedented demands for other material. Such changes were, in most instances, dictated by combat experience. In that event there was no alternative but to "change horses."

Requirements

The development of new types of equipment was the continuing mission of laboratory and research facilities throughout the war. War-stimulated research produced more scientific developments than would have resulted from many years of peacetime experimentation.

Chaos created by type changes was intensified by continuous alterations in quantity requirements. Constantly increasing applications for aircraft, tanks and other motorized vehicular equipment was reflected in comparable increases in requirements for communications. Unforeseen combat loss resulted in additional heavy replacement demands. Frequent changes in tactical plans, necessitated by combat experience, caused wide fluctuations in the requirements and procurement patterns. Additionally, the trend toward the application of the science of electronics to the implements of warfare procured by other services, created vast new needs for equipment.

Such rapidly changing conditions created great disturbances in the industry. It was all but impossible to plan very far in advance to secure the quantities and types of production facilities

required to meet military demands. Consequently, it was necessary to add expansion upon expansion. In some cases plans for new facilities were augmented and revised as often as six or eight times during construction. The resourcefulness of the industry in overcoming these seemingly insurmountable problems is reflected in the unparalleled production records which were established.

The first war procurements included over 200 types of development items, requiring a high

The famed EE-8 field telephone: heart of our communications.

degree of technical and production skill in their manufacture and close adherence to rigid specifications. A few of the larger companies had assisted in the development of these items and possessed the staffs of technical and operating personnel required to insure quality production in the allotted time. The majority of the radio manufacturers, however, were experienced only in making simple home receivers and, naturally, contracts were placed with the few experienced firms to meet initial requirements.

It was obvious, however, that to continue this procedure would seriously overload facilities, create congestion in a few industrial areas, and result in inequitable distribution of the war load, with disastrous financial effect on the smaller companies. The Signal Corps was therefore faced with the problem of bringing new producers into the field, at the same time maintaining the high degree of quality required.

Sub-contracting

New facilities were achieved to a considerable extent by a program of sub-contracting, initially for major components and sub-assemblies, and, as conversion of the industry progressed, for complete equipments. Educational assistance on technical and engineering matters was furnished sub-contractors by the larger and more experienced organizations and, gradually, additional capacity was made available as the enginering and technical skills of these sub-contractors increased. The early WPB action in prohibiting production of commercial radio and phonograph equipment provided the final impetus to effect a complete transition of the industry to a wartime basis.

Development of new end-item producers provided sufficient prime contractor capacity to sustain early demands for communications equipment. However, repercussions of volume demand were far flung, reaching down into every element of the intricate substructure which supports the industry. The Signal Corps prime contractors are primarily engineering, development and assembly concerns, procuring the sub-assemblies and major components from sub-contractors who, in turn, purchase the smaller component parts, such as tubes, resistors, capacitors, from firms specializing in those items. The sub-contractors at the second-level were generally able to handle the increased volume of business, although they were hard pushed. It was the third echelon of the industry which received the full force of the impact.

Despite increasing attention during the first months of the war, knowledge of the component parts industry was still negligible. The situation was not considered serious by military and civilian government agencies and by prime contractors, all of whom generally agreed that no unusual amount of expansion would be required to assure an adequate supply, except perhaps in certain specialized instances.

The error of this assumption was soon apparent. The sudden influx of orders for component parts, many times in excess of production capacities, resulted in order backlogs impossible of fulfillment. By the end of 1942, in an effort to correct this situation, the Signal Corps had initiated many Government-financed expansions in the components field —for batteries, fixed and variable capacitors, quartz crystal assemblies, dynamotors, electrons tubes, alnico magnets, steatite insulators. Simultaneously, many manufacturers had undertaken expansion at their own expense, applying to the Signal Corps for "Necessity Certificates," under which the costs of such facilities might be rapidly amortized through deductions in income and excess profits taxes.

These first expansions served to solve the facility problems of most component manufacturers, and thereafter only minor expansion was necessary for the majority of items. Nonetheless, several components presented continuing procurement problems throughout the war, due largely to extension of their application to new and unforeseen wartime uses, and to continuing changes in design, dictated by tactical requirements.

Vacuum Tubes

As with other radio components in peacetime, production of electron tube manufacturers had been geared to that required to supply the radio manufacturers for commercial purposes. It was recognized from the beginning that military demand would exceed by many times the industry's capacity to produce and considerable expansion had been initiated even before the war began. What could not be foreseen, however were the phenomenal developments in electronics and the increasing trend of other services to adapt the technology to their operations. Also, Allied needs for tubes increased the

quantities and types required, necessitating still greater production capacity. As a result, the tube industry was under continuous expansion and fluctuation.

Expansion for tube manufacture accounted for about 30% of the Government funds expended for Signal Corps sponsored facilities, and resulted in tube production increases from 36 million dollars in 1939 to 391 million dollars in 1944. Such tremendous growth placed a heavy burden on the comparatively few manufacturers in the industry. That they were able to respond so capably is a testimonial to their ingenuity in stretching their technical and production skills to the utmost. This was accomplished to considerable extent by the establishment of "feeder plants," which performed the less skilled work, leaving the principal factories free for the final and more exacting phases of production. Close coordination between industry, WPB, Signal Corps, and Navy on matters of tube production and distribution enabled all tactical needs for tubes to be met.

Expansions of numerous auxiliary facilities were required to supplement the expanded tube industry. These included a large operational increase by the only United States producer of the rare metal, tantalum, several expansions of producers of tungsten and molybdenum, and an expansion for production of glass-working lathes.

Radar

Probably the most glamorous and highly publicized weapon of modern warfare, outside the atomic bomb, is radar. The rate of facility expansion in the radar field was tremendous. Prior to the war, production was negligible and only a few companies were experienced in the engineering and technical skills involved. Increasing demand for radar throughout the war was borne by the few firms which had pioneered in microwave development, and which were already operating at top capacity.

In order to utilize the skills of these organizations, the Signal Corps provided Government-financed facilities for radar production at a cost of about 26 million dollars. The increasing demand for radar is demonstrated by the fact that in 1942 radar production had increased to 81 million dollars, about one-tenth the volume of radio production; in 1944 radar about equalled radio production, amounting to approximately 1398 million dollars; and during the first six months of 1945 radar production surpassed radio by 341 million dollars. Even up to V-J Day new requirements for radar were developing, and facility expansions were being constantly initiated.

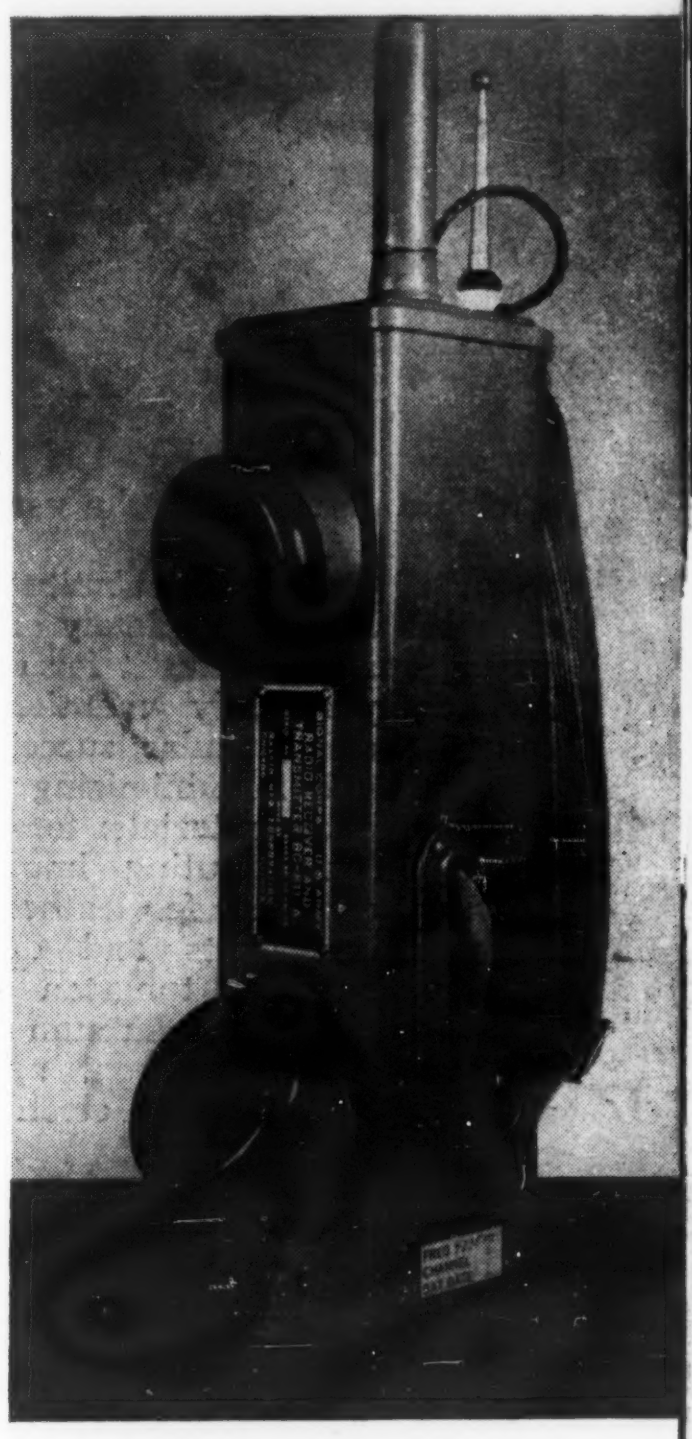
Wire

During the planning years it had always been recognized that unusual problems would surround procurement of Army communication wires in wartime. As a result of studies made during those years, much valuable knowledge concerning production methods and possible sources of supply had been accumulated; "Educational Orders" had developed a large amount of potential productive capacity. However, due to unprecedented and unforeseen demands, shortages in all types of materials, radical changes in specifications and in facility requirements and other unstable and fluctuating factors, wire procurement was a persistent problem. Over 22 million dollars of Defense Plant Corporation funds were provided for Signal Corps sponsored expansion in the wire and cable field, while additional facilities, valued at a little less than nine million dollars, were provided through private financing.

The facility problem was aggravated by changes in specifications effected in the latter years of the war in the interests of rubber conservation, requiring a complete change-over from crude rubber insulation to synthetic. Existing facilities were adaptable only to rubber insulating processes, and it was necessary to discard those facilities and provide others suitable for synthetic processes. As a result, by 1944 crude rubber requirements had dropped from a 1943 peak of 12,000 short tons to 1500 short tons, and by 1945 it was completely eliminated. Despite the unprecedented production peaks achieved, stocks of wire were never in excess of demands although there is no reason to believe that operations were ever retarded due to lack of wire.

Raw Material

An important phase of procurement was the task of assuring a smooth flow of materials to manufacturers of Signal Corps equipment. This job involved many functions and required the services of a large number of people. Briefly, it included determination of the amounts of materials required by Signal Corps contractors, taking action to assure proper distribution, and



SCR-536 achieved the ultimate in compact radio equipment.

a timely and uninterrupted flow of materials to contractors' plants; supporting priorities requests and materials expediting; initiating expansions of materials processing facilities where major Signal Corps interests were involved; prosecuting of intensive materials conservation and substitution programs; and recommending stock-piling or changes in manufacturing processes or in specifications where necessary to

Automatic switching equipment at Fort Benning, typical of Signal procurement.

eliminate or minimize the use of critical materials.

One of our major substitution successes was in completely eliminating our requirement for rubber, as previously mentioned. Other less spectacular successes were attained in minimizing use of many other materials; for example, in substituting impregnated cotton fabric for leather in cases, straps, belts and other articles; tantalum, tungsten and molybdenum for platinum in radio tubes; and rayon, nylon and cotton for silk in electrical coverings.

Expansion

The following table shows the amount of industrial expansion sponsored by the Signal Corps, either directly through the use of Government funds (Defense Plant Corporation), or indirectly through approval of applications for "Necessity Certificates":

Item	Gov't Funds	Private Funds & Necess. Certif.	Total
Batteries	$ 8,455,161	$ 664,125	$ 9,117,286
Capacitors	2,481,690	3,871,372	6,353,062
Electron Tubes	31,952,825	14,923,058	46,875,883
Inductors & Transformers	172,725	1,443,734	1,616,459
Meters	80,636	1,176,885	1,257,521
Meteorological	.....	467,441	467,441
Photographic	139,838	312,311	452,149
Plastics	.....	5,458,641	5,458,641
Quartz Crystals	1,736,512	1,508,279	3,244,791
Radio & Radar	26,952,767	21,520,048	48,472,815
Resistors	2,923,693	1,963,148	4,886,841
Rotary Equipment	707,125	5,293,905	6,001,030
Telephone Services	.....	7,362,722	7,362,722
Steatite & Substitutes	4,526,598	1,913,834	6,440,432
Wire & Cable	22,022,521	8,759,463	30,781,984
Wire Communications Eqpt.	2,127,070	8,053,444	10,180,514
Miscellaneous	3,278,040	9,179,411	12,457,451
GRAND TOTALS	$107,557,201	$93,871,821	$201,427,022

The following figures on orders placed by the Signal Corps during representative periods shows the contrast between prewar and wartime purchasing activity, and gives some indication of the rate at which the procurement program developed:

Year	Orders Placed	Value
1930 (Normal Peacetime)	2,400	$ 2,299,181
1939 (Limited Emergency)	4,300	6,097,128
1943 (Wartime Peak)	74,000	$3,070,761,000

Just prior to V-J Day, field operations were centralized in Philadelphia Signal Corps Procurement District, which is now designated as the sole Signal Corps Procurement District, responsible for all operations. The emphasis in current procurement is being placed on research and development in the communications and electronics fields, which will constitute a continuing study for the future.

The second industrial mobilization planning program is now being developed under the direction of the Army-Navy Munitions Board. The Signal Corps has established a new planning organization, divided between Washington and the Philadelphia office, which is accumulating the procurement experiences of the past war and performing the basic studies which will be required for active participation in the new planning program when it is fully formulated and published.

Brigadier General C. H. Arnold has been Chief, Procurement and Distribution Service, OCSigO, since January 1946. He received the degree of Bachelor of Science from Mercer University in 1915 and later an A.B. from the same school. A graduate in 1927 of the Army Industrial College and with supply experience as head of the Chicago Procurement District and on procurement duty in the Assistant Secretary of War's Office, he was especially well qualified to direct the post-war supply work for the Signal Corps. He is also a graduate of the Signal School, the Command and General Staff School and the War College. He saw combat service with the Infantry in France in World War I. During World War II he served successively as Signal Officer of the 8th Division, IV Corps, Second Army, and of Service of Supply, U. S. Army Forces in Australia from 15 January 1942, immediately after Pearl Harbor. Later he was Commandant of the Central Signal Corps School at Camp Crowder, Missouri.

Attack convoy approaching Mindoro, P. I., 1944.

Fires set by German artillery silhouette Signal Corps cameraman.

Democracy comes to Japan. Emperor Hirohito addressing Diet.

Communications in the South Seas. A radio operating hut.

United Nations Political and Security Committee in session at Lake Success.

Pigeons with the 1st Cavalry Division. Ami Islands, Admiralty Group, 1944.

After 3 years imprisonment, American mothers and children born in concentration camp are released at Manila, February 1945.

A.P.S. photographer records artillery fire with medieval cathedral at Argentan, France as backrop.

EDITORIAL

Industry

World War II's most striking lesson was that the combat soldier, on the ground, at sea, or in the air, is dependent for ultimate victory on the men who make his weapons and his supporting equipment. Military men, especially, realize that production and distribution are of first importance in winning a modern war. Few, if any, of our professional military leaders are overlooking the importance of this principle in plans for the defense of America.

Communications and photographic officers, primarily Signal Corps personnel, realize, of course, that *close* study by them will have to be limited to a small section of the broad field presented by overall national defense planning. ASA's membership lists indicate, fortunately, that specialists in the several industrial fields acknowledge their responsibility in this matter and that communications personnel of the Armed Forces can rely on them to bear their part of the load when called upon.

Many of the most capable men of industry came into the Signal Corps and the Air Communications Service in advisory of administrative positions. Some wore the uniform; some did not. They brought with them the vast experience gained in industrial organization and technical procedures. They were invaluable then, equally so now.

Industry is the most important segment of American life. As it is the basis of our national economy, it must also be the cornerstone of our national defense. To provide the means of intercourse between industry and the military, the Army Signal Association is committed to a need that is even more urgent now than after World War I, because modern technology has neutralized the geographical insularity with which we formerly consoled ourselves.

The features which make industrial mobilization a must may be summarized as follows:

a. Without industrial planning and mobilization, it is questionable that we can remain an important military factor.

b. Modern concepts of air warfare make it extremely doubtful if any allies can hold off an enemy again while we arm ourselves.

c. Industrial planning must be a peacetime function if it is to be effective in war.

d. This planning must cover: raw materials, subcontract facilities, manpower, and production facilities, including space, equipment and tools.

e. Arrangements should be made between industry and the services to grant furloughs to selected key personnel of industry and send them as students to the Industrial College of the Armed Forces.

The War Department is moving with commendable speed to accomplish its share in industrial integration. Activities of the Army-Navy Munitions Board and the creation of a Research and Development Division in the War Department General Staff give promise of concrete results. Brigadier General R. W. Johnson, wartime vice-chairman of the War Production Board, recently focussed attention on another phase of planning when he called on government and industry to join in developing plans to protect industries essential to the Nation's defense, including dispersing these facilities, even locating some of them in underground caves to prevent their destruction in atomic and rocket warfare.

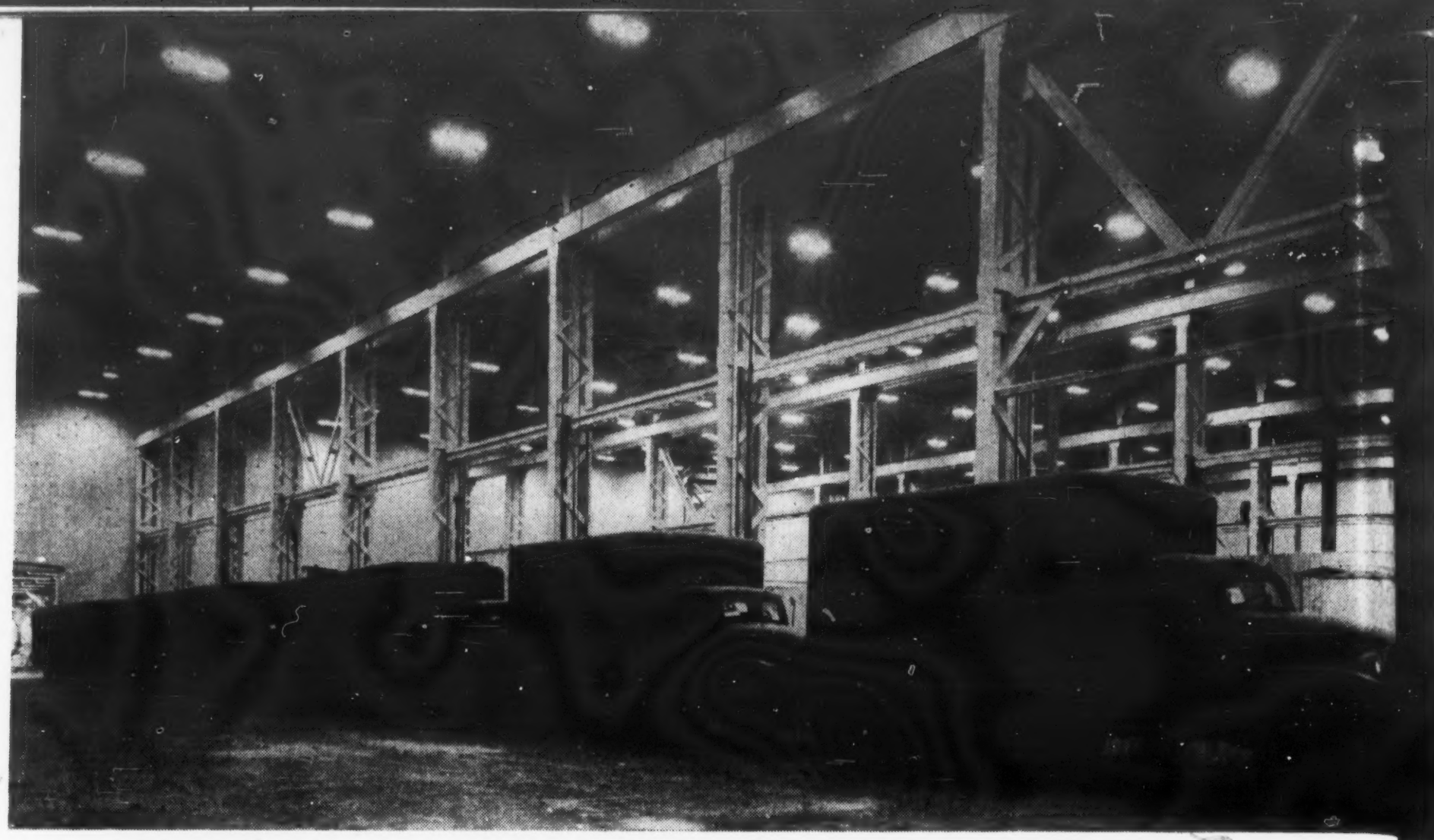
We agree with Mr. Troyer S. Anderson who says in his Infantry Journal articles that "we ought not to forget the debt the Nation owes the far sighted officers who worked on procurement planning in the office of the Assistant Secretary of War and in the supply services during the peace years." In this we differ with Mr. Donald Nelson in his condemnation of the military leaders in the War Department's Service Forces. We would like to hear their version before we agree with the editors of another service journal in accepting Mr. Nelson's criticisms and stating that the "GHQ mind made a mess of things." But perhaps it would be just as well to let one of America's greatest industralists, Mr. M. W. Clement, President, Pennsylvania Railroad, speak for them as he did on October 4, 1946, when he said:

"But, through all the war—and giving due credit to all the endeavors of the railroads as well as all industry—the Armed Forces were supreme. It is not necessary to emphasize here the magnitude of the war job performed by the industries of this country. But the point I do want to emphasize is that never in the history of the world was there a more efficiently and better organized Army and Navy than the Army and Navy of the United States in the past war—coming up from almost nothing as they did to the millions who served well. It is to the undying credit of the Captains and Majors and Lieutenant Colonels of the Regular Army and to their counterparts in the Regular Navy, who took over the positions of Major and Lieutenant Generals and Admirals and who built up the organizations to function as they did.

"The Chief of Staff, the Chief of Services of Supply, the Chief of Transportation-Army Service Forces, all will long be more than names to the railroad men of the United States. They built up a great organization. No one, speaking from the standpoint of rail transportation in the United States, can ever be too complimentary to the Army and Navy."

Industrial Mobilization

These wartime words of the new Secretary of State Marshall point up the key spot occupied by Industry in military planning: "There is another phase of scientific research which I think has been somewhat ignored—the development of expeditious methods for the mass production of war materiel. This is of great importance since it determines how quickly we can mobilize our resources if war comes and how large and costly our reserve stocks of war materiel must be. We can be certain that the next war, if there is one, will be even more total than this one . . . It should be assumed that another reconversion from peace to war production will take place initially under enemy distant bombardment . . ."



Largest U. S. radar, built by G. E. for Army. Requires these seven trucks for transport. An undisclosed number of these "super sleuths" have been built for permanent secret installation at strategic locations.

THE WAR AND GENERAL ELECTRIC

By S. W. Upham

Government Division, General Electric Co.

GEOPOLITICS and the Nazi plan for world conquest failed to devise a weapon that could neutralize the democracies' industrial superiority. In that failure, Adolf Hitler remained a megalomanic paper-hanger rather than becoming the modern Caesar that he could have been had his Wehrmacht achieved its objectives.

American industrial resourcefulness insured the ultimate victory to our forces. Typical among the large manufacturers is the record of General Electric. At the peak of the war, G.E. was producing radio and radar equipment at a rate more than seventeen times greater than before Pearl Harbor. For the Army alone, the company produced 134,000 major equipments with an aggregate value of over $300,000,000.

Production of this magnitude was made possible by a number of factors: long experience in electronics; large research, engineering and development facilities; extensive and rapid expansion in plant capacity and personnel; special training programs for new employees; and liberal employment of sub-contractors.

Early Developments

G.E. radio activities date back to 1903 when Charles P. Steinmetz designed a 10,000-cycle, 1-kilowatt alternator for Fessenden's pioneer experiments. A few years later, Dr. E. F. W. Alexanderson developed a 50,000-cycle, 1-kilowatt alternator.

At that time the effective use of radio was severely limited by the low power of the transmitters. A practical generator to produce more power was an urgent need. Dr. Alexanderson tackled this problem with vigor and determination. Progress was slow, but he eventually completed a powerful 200-kilowatt generator that became the foundation of the first great transoceanic radio system. Meanwhile, Dr. Irving Langmuir was developing the high-vacuum tube, without which modern radio could not exist.

General Electric's participation in radio activities in World War I was three-fold. It produced Alexanderson alternators in 50 and 200 kilowatt sizes, manufactured various types of transmitting and receiving tubes for the Army and the Navy, made aircraft transmitters and receivers for the Navy, and produced large numbers of powerful searchlights for aircraft detection.

Following the war, G.E. electronic engineers turned their attention to improved methods of aircraft detection. In 1928 Dr. Alexanderson devised a method of obtaining the altitude of an airplane by directing a radio beam downward to the ground and picking up its reflection. Experiments were extended to the detection of planes in the air by using one-meter radio waves. Another series of tests was conducted by Chester W. Rice, using radio waves of between one and ten centimeters. Automobiles on a nearby road were detected at a distance of 1¼ miles, and a small plane at one mile.

Simultaneously, at the company's Research Laboratory and Radio Department, newly established in 1920, experiments were actively conducted in radio communication and television. Dr. Albert W. Hull invented a new tube, the "magnetron," which could be used to produce radio waves of very high frequency and of considerable power. In 1923 the company introduced the thoriated tungsten filament, which

greatly reduced the power consumption of radio tubes. Climactically, G.E. developed the screen-grid tube, the heart of the modern radio receiver.

Throughout the period between the wars, General Electric was active in producing radio equipment for both the Army and the Navy. The first 10-kilowatt, high-frequency radio transmitter used in the Army fixed station system was installed in the new WAR transmitting building at Ft. Myer, Virginia in the spring of 1929. With this equipment the Army radio net was greatly expanded, linking Washington directly with headquarters in most of the Corps areas, and with Panama, Hawaii, Alaska, and the Philippines. Installation was made under the direction of Capt. Frank E. Stoner, now Major General. The equipment served faithfully for 14 years, until it was replaced in 1943.

In 1936 the company was awarded a contract for liaison transmitters for aircraft, amounting to $1,620,000. At that time, this was the largest single U. S. Government contract ever placed for radio material.

Radar

General Electric started production in 1941 of air search radar. The detection of aircraft, however, was only a part of the defense problem. It was equally important to identify friend or foe. The Signal Corps asked G.E. to develop recognition equipment for this purpose. The general requirements were stated, and the company was given the job of designing the apparatus.

Work began immediately and the first IFF set was delivered to the Signal Laboratory at Fort Hancock, New Jersey, in the summer of 1941. The trials of these recognition sets were entirely satisfactory, but before they could be put into production, it was decided to use the British type of equipment in order to coordinate means of identification among the allied nations.

Development of anti-aircraft radar fire control in the company was also in progress. The first experimental apparatus was built by Radiation Laboratory at M.I.T. Then, in late 1941, the Laboratory asked G.E. for a production model. The company's engineers also began work on a modified design that was quickly adopted by the Army and became the widely used SCR-584, a mobile unit, trailer mounted. It was used at the Anzio beach-head in February 1944 and later employed for a variety of purposes by both the Army and the Marine Corps.

General Electric also participated in the development and production of many other types of radar. One of these, the APS-10, a lightweight airborne search set, was produced for the AAF during the last few months of the war.

During the period when radar control of anti-aircraft guns was still in the development stage, visual aiming had to be used with searchlights for night spotting. Many improvements in searchlight design were produced by G.E., culminating in a 60-inch light, rated at 800,000,000 candlepower. So powerful were these lights that a person could read a newspaper in an airplane at night at a distance of 12 miles from the light source.

Radio Communications Equipment

In the period preceding World War II, much attention was given to providing improved types of military communications equipment. Technical problems involved in the evolution of the new units were extraordinarily difficult. It was necessary that the apparatus be light in weight, occupy a minimum of space, and be of exceptionally sturdy construction.

To complicate the problem further, nearly all types of equipment were required to cover wider frequency bands, provide rapid and extremely simple means of adjusting frequency, and maintain the desired channel to closer tolerances. The widely-used BC-375 transmitter, part of the SCR-287, was already in production at Schenectady by December 1941. This became a standard item and over 70,000 units were produced during the course of the war.

The company, which for some years had been making the transmitters for the SCR-193, was asked to undertake the design of a replacement set—the SCR-506. This set represented a number of radical departures in design practice. The specifications demanded a complicated circuit in a very small space, along with rigorous shock and vibration require-

G. E. engineers display VT fuze with bombs and airborne rocket.

INDUSTRIAL MOBILIZATION WAS THE SECRET WEAPON THAT MASTERED THE BLITZ

Radar "jammer" TDY-2, principal countermeasure unit of Army.

G. E.'s 800,000,000 candlepower, 60-inch anti-aircraft searchlights.

ments. The difficult job was finally completed and experimental models were submitted for approval late in 1941. Over 17,000 of these equipments were produced for the Army Ground Forces.

Additional Plant Capacity

All this activity required a tremendous increase in plant capacity. Demands for radio equipment had increased rapidly long before Pearl Harbor. To meet them, the company built a large new structure, Building 81, with 160,000 square feet, at Schenectady, to house the Transmitter Division. Later a second structure, Building 269, also 160,000 square feet, was constructed to house the Tube Division. Facilities of the Receiver Division, located at Bridgeport, Conn., were converted and expanded, adding 325,000 square feet of engineering and manufacturing area.

Then came quantity production of radar. The remarkable success of radar in the Battle of Britain foreshadowed a tremendous demand for this equipment for U. S. Armed Forces. Indications were that the company's total output of both radio communications and radar equipment would have to be doubled over the expansion already made to meet the demands of the Army and Navy.

Not a square foot of space was available in the Schenectady Works because of similar expansion programs in other divisions. Twenty-four acres belonging to a former wiring supply manufacturer were proposed for a new site. An existing plant was found to have 60,000 square feet that could be reclaimed without much difficulty and considerable space was available on the property for a new 300,000 square foot plant.

The company's Defense Coordinating Committee quickly endorsed the proposal and assistance of the Government's Defense Plant Corporation was enlisted. The project was approved. Company representatives proceeded to Washington and within two weeks the owner of the factory had signed a contract for the conversion. A few days later the old buildings were being cleaned out and the construction of a new plant was being planned. Scarcity of materials delayed progress, wood trusses for the roof had to be substituted for steel, but a fully equipped factory was in operation within four months: the Campbell Avenue Plant on the outskirts of Schenectady.

Later, at Syracuse, N. Y., a street car repair shop of 150,000 square feet was converted into a factory for making radar equipment, and then the Reconstruction Finance Corporation built an entire new plant at Thompson Road, Syracuse, and leased it to G.E. for radio and radar production. These facilities added 260,000 square feet for electronics engineering and production.

Since the conclusion of the war, headquarters for General Electric's electronics activities are being centered at Syracuse, where

the company is now building "Electronics Park," a completely new plant of some 1,200,000 square feet.

Employees

Before the war General Electric employed about 76,000 workers. At the end of hostilities the number was about 170,000. Some of the new employees were on a part-time basis. Men and women who worked in the company's offices during the daytime went into the shops and added a short shift in the evening. Lawyers, real estate brokers, insurance salesmen, clerks in stores and many others worked in the factories after hours. When the afternoon bell rang in Schenectady schools, many teachers and students hurried down to punch the time-clock at the G.E. works. At least one minister worked the night shift, taking Saturday night off to rest for his Sunday sermon.

As the war continued, women came to work in increasing numbers, both in the offices and the factories. Former music teachers, ex-newspaper writers, a retired head waitress, a minister's wife, numerous grandmothers, and hundreds of housewives helped produce weapons of war at General Electric plants throughout the country.

Some former beauty shop workers found that dexterity developed in curling hair was valuable training for delicate assembly operations. Hundreds of women were trained for drafting work. Numerous college girls, mostly graduates in mathematics and physics, were assigned to engineering duties. Some women drove trucks. Others became machine-tool operators. In 1940 women numbered 20% of the company's employees; in 1944 they constituted 40%.

Training new employees was a difficult task. Aside from the new employees, there also was the problem of retaining, and sometimes retraining, the older employees on new jobs. To accomplish this gigantic task, G.E. broke down every job into simple elements. The working cycle of each element was shortened, thereby accellerating the efficiency and shortening the training period.

Men and women from all walks of life became specialists in their operations in a very short time. This, however, did not produce good all-around mechanics, but it did quickly solve the emergency problem. Where an operator showed outstanding qualities he was quickly advanced to a more skillful job with a higher incentive. By a combination of these methods and instruction, higher levels of skills were attained in shorter periods. Production increased and heavy demands were met in the machine shop, assembly and testing sections.

Dividing the Production Load

Even before Pearl Harbor, General Electric had been hard pressed to meet the production demands of the national defense program, and the company had turned to smaller manufacturers throughout the country to do certain parts of the job. The work done by these sub-contractors included metal stampings, forgings, castings and gears of all sizes and types, as well as a variety of machine work and sub-assemblies.

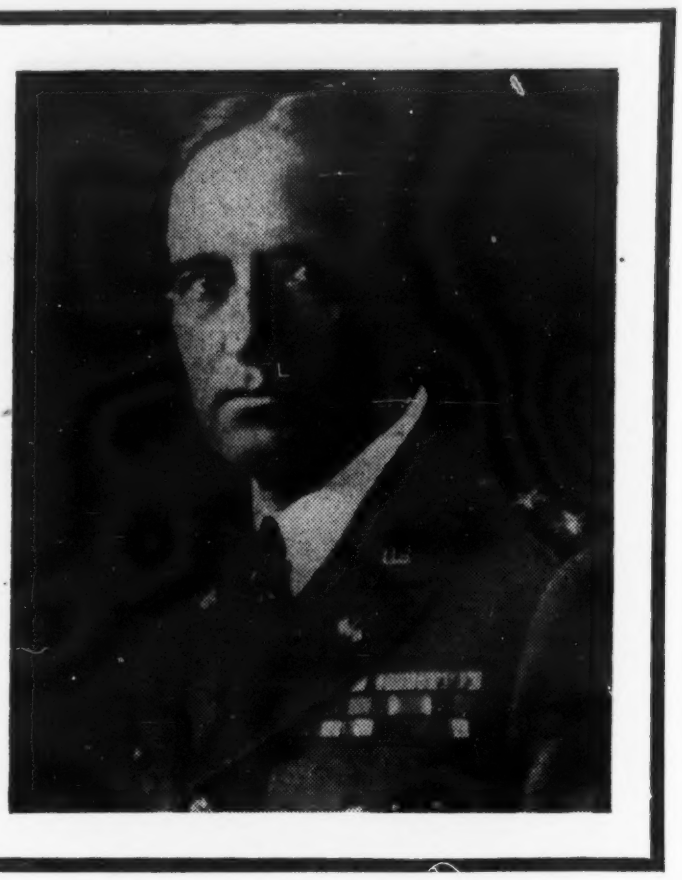
Besides the instances where General Electric remained the prime contractor, when it sub-let part of the work to others, there were numerous instances where the company turned over its designs and drawings to other concerns which were additional prime contractors or sub-contractors on the same product.

At a stockholders' meeting at Schenectady on April 21, 1942, President Charles E. Wilson pointed out that: "Men who go to war give not only their time and money to their country, but some part of themselves. In this emergency, corporations can do

Principal elements of APS-10, AAF light weight radar.

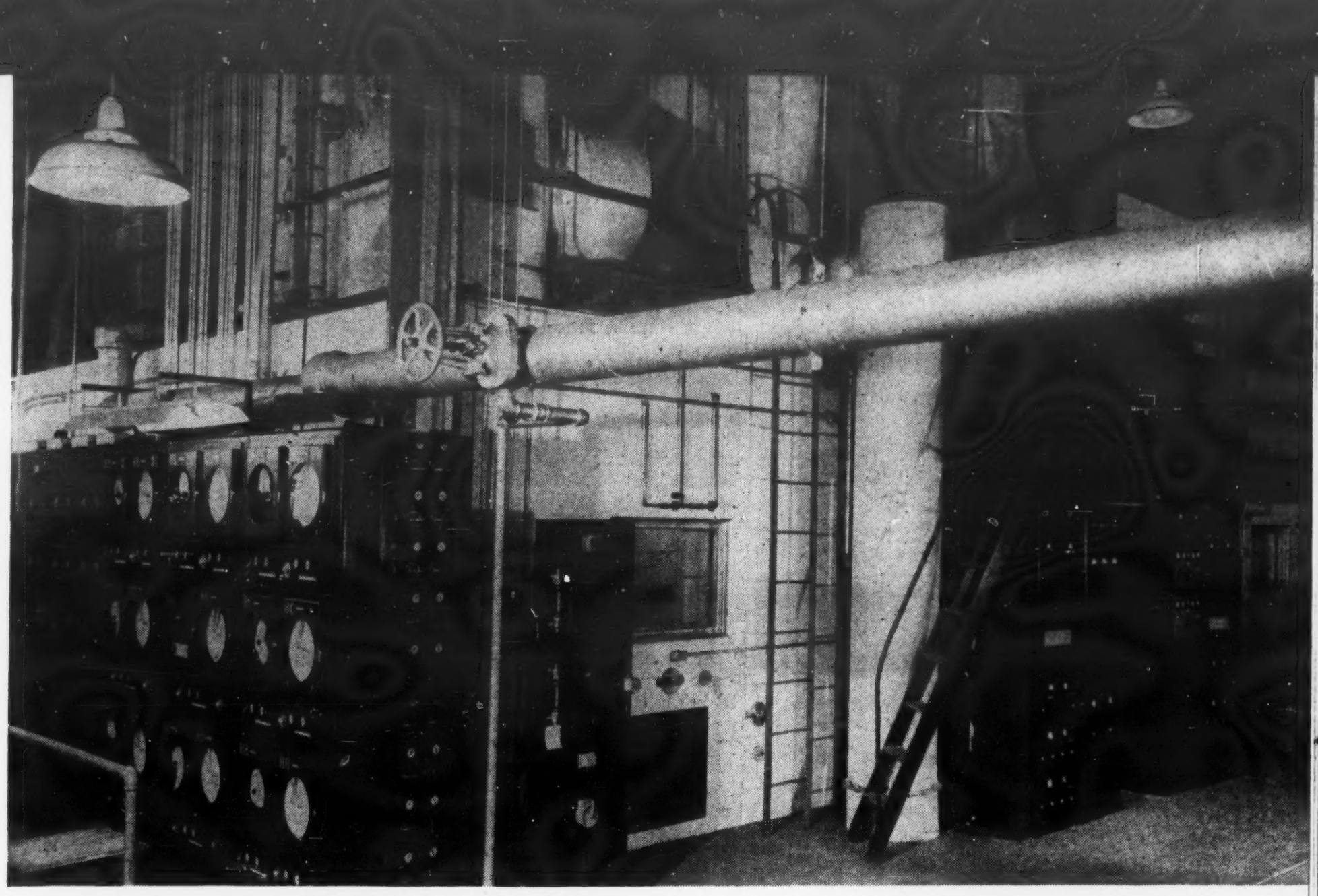
no less. We have freely given to others, many of them our competitors, so that the production job might be enlarged and speeded, our designs, our patents and our experience; the only things we have to give in addition to our own efforts. Before Pearl Harbor, we agreed to make available any of our designs and techniques that may be required by the Army or the Navy, for manufacturing by others, whether patented or unpatented. I repeat that offer again now, for the record, to hold good for the duration of the war."

Before the war was over, General Electric participated in the design and manufacture of more than 100 different kinds of radar and radio sets for the armed forces. In some instances, the design was entirely the product of the company's engineers; in others it was developed elsewhere and the company's responsibility was the manufacture of the equipment. In some instances the company was the only supplier; at other times the manufacturing responsibility was divided. Often the company made some components of a particular set while the remainder were made by others. One of the largest of General Electric's war assignments—electronic production was a tremendous project, amounting, at the peak, to about a million dollars a day.



GENERAL GEORGE S. GIBBS

The death on January 8 of Major General George S. Gibbs was sad news to his host of friends and those who were his loyal subordinates during his long and brilliant career in the Army. A charter member of this Association, he was one of its most enthusiastic and distinguished supporters. As long ago as March 1946, before ASA was formed he contributed his counsel toward the plans for its formation. General Gibbs retired from the Army 1931, after completing his service as Chief Signal Officer of the Army. He had fought in the Spanish-American war and served as a Brigadier General in France in World War I. In between wars his achievements included building the north central section of the Alaska Telegraph System, and service as Chief Signal Officer of the Army of Cuban Pacification, installing a chain of radio telegraph stations throughout Cuba while there. He worked at The Hague both as advisor to John Bassett Moore in revising the rules of war and as U. S. delegate to the international convention of radio communications. After leaving the Army he continued his contributions toward better communications in America by serving as president of the Postal Telegraph Company. America has lost one of her most distinguished citizens and servants; the Army has lost an officer and gentleman who throughout his life lived up to the highest traditions of the military service.



DEVELOPMENT. Before experimental models of military equipment become standard, they must pass severe heat and humidity cycles, salt spray and other exposures. Here is one of SCEL testing chambers.

SIGNAL CORPS RESEARCH AND DEVELOPMENT In Peace and War

Technology Against the Axis: Part I in a Review of Electronics at War

By HAROLD B. CHURCHILL

Major (Sig. Res.)

This Spectrograph measures as little as a half-microgram of impurity in battery electrolytes, examines tube elements, steel structure and ceramics.

PLACING any dimension upon the Signal Corps' research and development program in wartime is difficult, regardless of the yardstick you apply.

Use dollar volume or man-hour figures and they lose significance from sheer size. Then too, any program examined would only in part represent the Signal Corps because of the contributing services, agencies and industrial corporations which were first and last an integral part of the program. In addition, without American productive know-how, assistance from other arms, the Navy, Allied nations, and NDRC, all of which deserve great credit, no such program would have been possible.

All in all, any brief look at signal development must omit the names of those many individuals and organizations who have contributed so much to the common end, and therefore can be only an extract of contributions to the Signal Corps' program.

From the start, this accelerated military engineering mission was a race for technical superiority on the battlefield to out-pace a German army and air force strongly supported by a large research and development program.

Calibration chamber designed and built by SCEL engineers is used for extremely accurate and delicate calibration of mercurial barometers.

All military storage batteries are exhaustively tested. This testing panel is used at SCEL.

This race placed a high premium on fast production of radically advanced devices, the first target of Signal Corps engineering and technical organizations which aimed much of their effort at accelerating this production.

In this rapid development and production for the combat and supply services, the Signal Corps' technical activities ranged virtually from equipment conception to delivery, performing research, development, design and improvement of signal equipment; writing specifications, preparing drawings and procurement data; inspecting production; and setting up test, maintenance and repair requirements for the field. And once off the production line, engineers frequently delivered and installed equipment in the field, giving technical guidance to combat units.

Later, troops assigned to the Signal Corps Engineering Laboratories took first production models overseas, testing and demonstrating performance and putting equipment through its paces in combat.

Signal Corps' engineering interest in each of several thousand items whether in peace or war is never finished until each type of equipment passes into the limbo of the obsolete to be wholly replaced by a succeeding type. Performance in training or combat is closely followed and weighted, with thought given to a more efficient and often radically new type of successor.

In fact this search for new electronic devices at the Signal Corps' laboratories led to early experiments with 9-centimeter radar just about eight years before hostilities of World War II, later turning to lower frequencies because of the higher power and greater receiver sensitivity then available. Signal Corps experiments on these frequencies led to the first military radar capable of tracking in azimuth, elevation and range—a 10-kw peak power unit whose performance against planes was witnessed by the Secretary of War in May 1937 and described to the President as a "remarkable scientific advance." It was—for those days!

Meantime, side by side with these radar experiments, the Signal Corps Laboratories were pressing development of infrared heat detection devices. These units, set up at the New Jersey side of New York harbor, were tracking incoming and outgoing vessels completely unknown to their passengers or crew.

The German line *Bremen* and the British *Olympic* were followed on their outbound course to the horizon ten miles away, while at dusk of 25 September 1934 the *Mauretania* was tracked by her heat long after she had disappeared into the haze at a distance of 14 miles. Then further changes were made: thermopile amplifiers together with improved detectors were added. Tankers and freighters entering Ambrose Channel were checked at will, the *Aquitania* and 30,000-ton German *Statendam* followed to 20 miles. Then the *Normandy* was tracked by her heat 35 miles out to sea.

But while the Laboratories were rapidly improving devices both in the near and far infrared, it was soon apparent that weather and other causes imposed severe limits on aircraft detection by heat. For instance, such detectors turned out their best performance only at night, and preferably when it was cold and clear. Then too, as near infrared sensitivity increased, appartus began responding to radiation from first magnitude stars, for instance Sirius. Pulse-echo radar systems, however, had none of these limitations—or at least not until microwaves of such short wavelengths were introduced that absorption again entered the picture.

The Army's first radar service test, held at Fort Monroe in the fall of 1938, tried the combined performance of both thermal and radar detection. SCEL's first model of the SCR-28 was put through its paces before the Coast Artillery Board, tracking planes at their maximum altitude of 32,000 feet and at a range of 50,000 yards. Among other things this test sounded the obsolescence of the lighter, cheaper but far less efficient sound detector which told where a plane *was*, but never where it *is*.

With the imminence of war in Europe, the all-out push went to radar. There were two good reasons: radar could be greatly improved, while the best infrared could always be undone by vagaries of the atmosphere.

A long range detector for coastal aircraft warning was the next major point of radar attack by the Laboratories. A pair of 50-kilowatt, 100 megacycle tubes were procured. Crews hastened to build an antenna four dipoles high and nine wide. A trailer for the antenna's support was purchased while engineers put final touches on a single-input superheterodyne. In August 1939 it was ready to operate at Sandy Hook, New Jersey, and test planes took off.

Tracking them successfully to 85 miles, the experimental radar warned of their presence up to 138 miles. Built piece-by-piece in the Laboratory shops, this unit later became one of the best known Allied radars—the SCR-270. It was this set which detected the Jap planes on December 7, 1941. Unhappily they were interpreted as a flight of U. S. planes coming in from the mainland.

Even before the onset of hostilities, Signal Corps radar development rapidly expanded in many directions. Both research and development contracts were let with the country's leading manufacturers for a number of radar types. NDRC opened the Radiation Laboratory at M.I.T. and a steady flow of microwave components and equipments followed, increased by similar results from industry.

Urgent need for gun-laying, harbor surveillance and searchlight directing equipment led to the SCR-296, SCR-547, SCR-584, SCR-545, AN/TPL-1, and AN/MPG-1. Later the lightweight early warning AN/TPS series was produced when our forces began rapidly advancing into enemy territory, needing portable, highly mobile detection equipment. British experiments led to the American development of such GCI radars as the SCR-588, SCR-527, and SCR-627, while later refinements in microwave radar produced the SCR-615 and the AN/CPS series capable of tasks formerly requiring several types of radars.

Concurrent with the development and production of these radars, suitable associated IFF equipment for each application emerged to recognize and identify friendly aircraft. Within a 20-month space, due to all-out development effort production of new types increased many times.

Radio

Parallel to prewar radar development, a concerted point of Signal Corps attack was the design of new ground radio equipments to provide communications for fast, mobile offensive operations. One phase was the design of tank radios equally tough as the tanks themselves to withstand the hammering of rough terrain. Further-

SCEL tube engineer working with radar-tube VT-158 developed by Laboratories. Device is a glass lathe.

PRECISION. Frequency accuracy, stability, output and performance of all equipment is measured with close tolerance. This secondary standard permits the exact design of battle-tough items.

more they had to be tuned by operators who couldn't take time off from the grim business of getting the enemy first to conduct the niceties of dial twisting.

These tank radios needed range and reliability regardless of climate, ignition interference, or mechanical roaring of motors. And there was the all-important question of signalling method—should amplitude modulation, long standard for military use be used? Or should the relatively new and tactically untried frequency modulation be put to work? SCEL proceeded to find out.

Through contracts with the Bell Telephone Laboratories the development of two identical tank radios was begun, one using amplitude modulation, the other FM. Concurrently the Signal Corps Laboratories designed and built two lightweight, small pack sets, one using FM, the other AM. Then tests began.

Competing FM and AM models were operated under gruelling conditions on all sorts of terrain, producing a consistent pattern of results; FM led by 3 to 2 in intelligibility range; at extreme range FM was 4 to 3 out in front. That settled the question.

The Signal Corps thereupon placed the production of FM radios in high gear, and the SCR-508, 510, 538, and 610 came into being, first to equip the 1st, 2nd, and 3rd Armored Divisions, being rapidly organized and trained for combat overseas, and then subsequently for major use throughout the various theaters.

Development of other new Signal Corps radio equipments was concurrently initiated prior to the declaration of war.

In some cases the entire development was performed in the Laboratories' screen rooms and workshops starting with a breadboard chassis; in most cases direct development contracts were placed with the country's leading radio concerns. Using arms performed service tests of the products in concert with the Signal Corps. Close teamwork between the Signal Corps Laboratories and manufacturers resulted in the production of the SCR-284, 299, 300, 499, 506, 511, 536, 585, 593, 619, and many others well-known on all battle fronts.

Perhaps the most significant of several rapid radio developments was the radio relay series, of which the first experimental models were shipped by the Laboratories to Africa in 1942 to span long distances from Algiers to Tunis. So successful for providing teletype circuits across North Africa, the experimental sets were called upon to provide substantially the only high-capacity circuit to the beachhead at Anzio, also spanning the Mediterranean to Sicily and Italy.

Concurrent with the shipping of the experimental sets to Africa, plans were made for a complete and finished system of radio relay networks for long distance, rapid multichannel voice transmission using existing wire terminal facilities, but with a radically new type of automatic radio relay system. Resulting developments were the AN/TRC-1, 3, and 4 series used by U. S. First Army for the main multichannel voice and teletype circuits from England to the beachhead in Normandy from D-1 to D-plus-12, and later to provide flexible communication for the rapidly advancing U. S. Armies in France.

RDF

While the Laboratories wartime program in radio and radar rapidly expanded, radio direction finding research and development proceeded as an accompanying basic means of probing the disposition and activity of the enemy through new intercept techniques, and as an appraiser of weather phenomena and meteorological conditions. And RDF assumed another and increasing role: guiding military forces over unknown terrain.

First and perhaps neediest undertaking was the development of modern communications intercept and direction finders to replace outmoded and virtually obsolete apparatus, a heritage from the inter-war period of inadequate military budgets and consequent technical unpreparedness.

On a round-the-clock schedule both the Laboratories and manufacturers under contract developed intercept equipment bridging enemy frequencies from 100 kilocycles to 160 megacycles. These new RDF's were transportable aural-null direction finders using Adcock antennas; automatic transportable finders with instantaneous indicators and man-pack DF's with loops. For warning of interloping enemy signals, panoramic receivers were developed under contract to sweep wide segments of the frequency spectrum. These intercept and other newly developed devices probed enemy communications, continually monitoring

and recording his messages.

Development of a VHF Fighter Control System was supervised by the Laboratories to meet requirements of the Air Forces Fighter Command and to net with the existing British VHF system for coordinated Allied action. Put to production in a remarkably short time and involving a hundred million dollars, it later became the nerve system backbone of the AAF Fighter Command and used in all theaters.

Two other phases of RDF development became extremely important: radio beacons, homing devices, navigational radio aids, and Sferics. Radio beacons were devised to permit Armored Force units to home on headquarters with ordinary receiving equipment, while homing devices were evolved to guide foot soldiers to their radio source. Navigational radio aids had a similar function: to coordinate mechanized movements despite highly fluid tactical situations.

The Laboratories have been likewise closely tied to Sferics research, the long range positioning of thunder storms. Using highly sensitive static direction finders with instantaneous cathode ray bearing indication, these equipments were and are widely used in storm-frequented middle-Atlantic, Mediterranean, Caribbean and Pacific areas. Of the Sferics equipment probably the most familiar is AN/GRD-1, which proved of inestimable value in charting the paths of thunderstorms supplementing and extending the range of weather data obtained by other means.

Syndicated newspaper writer and an editor of Time magazine, Harold B. Churchill was also active in signal radio communications research before the war. Commissioned in the Signal Corps in 1942, he was in charge of instruction literature on Radio, Wire, Power and other fields at the Signal Corps Laboratories, and later with the Radio Division, Signal Corps Publications Agency. He is now Chief of the Technical Information Staff, SCEL.

Wire

At the same time radio and radar were pushed to the hilt, development in concert with major manufacturers was pursued into wire equipment which, working hand-in-glove with radio was later to form the vast flexible network of army communications.

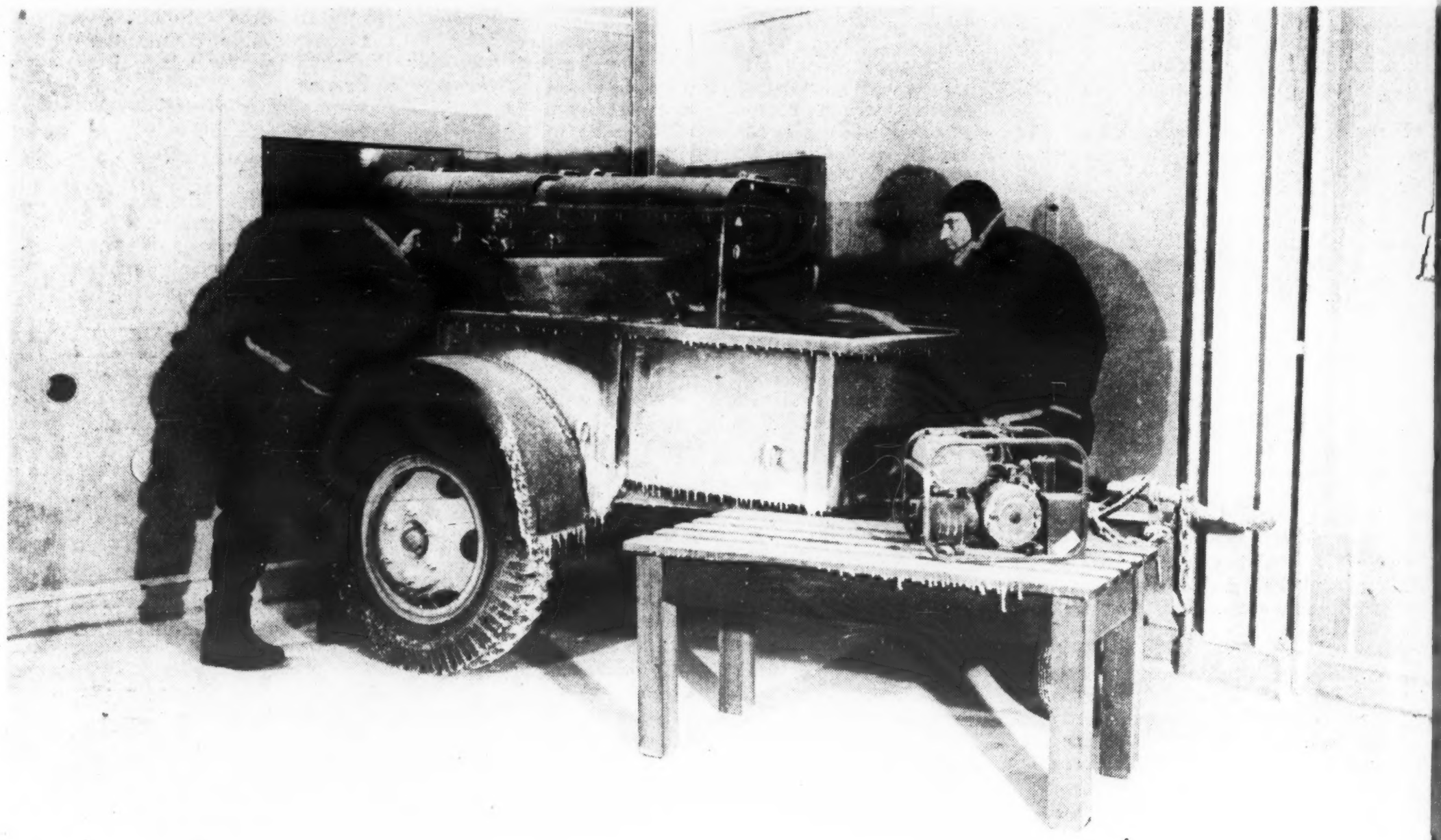
Well before hostilities it was recognized that the greatly increased mobility of modern war required a wire system which would keep pace with the rapidly advancing armored and motorized units. Existing pole line and cable systems developed for peacetime installation obviously couldn't cope with the increased speed of movement of division, corps and army headquarters. A high-speed military wire system was needed.

Accordingly, in early 1941, the Signal Corps, British Liaison Officers and Bell Laboratories engineers visualized a completely new type of system suite to rapid, fast-moving construction, and a development contract was placed with the Bell Telephone Laboratories for its design.

The result was the 100-mile spiral-four cable carrier system permitting simultaneous transmission of three telephone and four teletype conversations over a hundred or more miles which might separate rapidly advancing headquarters. By December of 1942 systems were shipped to North Africa after Louisiana maneuver tests revealed a great increase in construction speed and another important asset—a big saving in shipping tonnage and space compared to ponderous open-wire pole line systems.

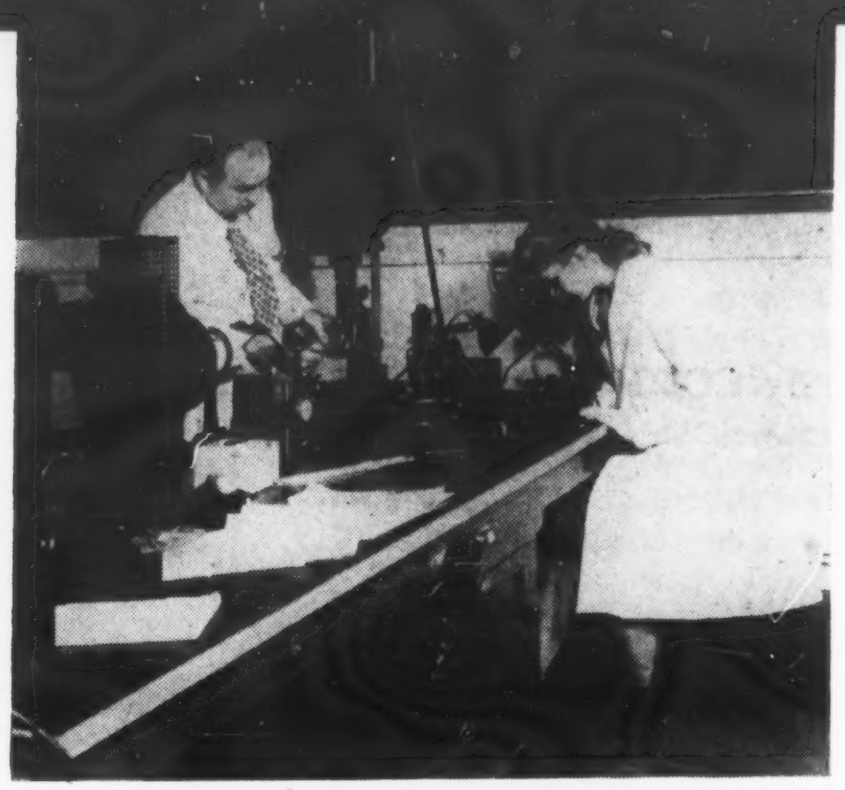
From then on, these new systems played an increasing role in speeding up our military communications. By the time General Patton broke loose for his spectacular thrust into France, another important element had been added to speed and increase the flexibility of spiral four. This new addition was radio relay which worked as an integral part of the spiral four system, bridging gaps in the cable, or supplanting the cable entirely when movement was so fast that even this rapidly-constructed cable proved too slow. Patton's unprecedented Third Army performance gave this mobile signal system its severest test.

While spiral four and radio relay were being produced and shipped to the theaters in quantity, further equipment development was stimulated. To improve transmission over field wire lines, the 4-wire repeater EE-99 and the 2-wire, 21-type Repeater EE-89



SUBZERO COLD ROOM. In testing chamber capable of housing a tank, engineers make adjustments on power unit prior to operation at subzero temperatures.

A magnetron tube is spot welded. One of the delicate operations performed by Lab men.



Components of signal equipment are subjected to intensive microscopic examination.

were delivered to the field. Likewise Telephone TP-9, an instrument providing amplification in both directions under control of a push-to-talk button, proving invaluable for long point-to-point circuits by doubling the range otherwise obtained by a conventional telephone set.

Other notable developments were the wire dispenser in which wire coiled in solenoidal form could be laid at speeds up to 100 miles per hour or, involving no rotating parts, could be laid by carrying on a man's back, from a moving jeep, low-flying plane or shot out of bazookas. Also developed were Teletypewriter Sets EE-97 and EE-98, and Telegraph Central Office Set TC-3. Just how widely these were used can be gauged by production figures: six thousand TC-3 central office sets and forty-odd thousand EE-97's and 98's.

When the Japanese overran rubber producing areas of the Far East they not only choked off the prime source latex supply for military tire production but throttled the flow for all-important wire and cable insulation.

All this came at a critical point when field requirements for rubber-using Wire W-110-B were alone topping 150,000 miles per month and engaging a major portion of the wire-making capacity of the country. Here again a major effort was required by wire and cable producers to convert rubber-using cable to synthetic substitutes. So closely coordinated were producers and our military laboratories that often alternate materials were tested and results submitted to manufacturers within 48 hours after samples were produced.

What first looked like a production catastrophe turned into a series of technical advances. New and superior synthetics produced Wire WD-1 with a third the weight of W-110-B and a 25% greater talking range. W-130-A and C came into being. Despite specification changes forced by the rubber shortage, production of field wire was increased to 185,000 miles per month.

Meterology

While everyone talked about the weather in 1940, Signal Corps engineers hastened to do something about meteorological equipment, some of which had been used since the close of World War I, and none of which was suitable for World War II—due largely to pitifully small Army meteorological appropriations of 1937 to 1940.

Large demands from all military sources just prior to U. S. entrance into hostilities stemmed from anticipated weather data needs for operations forecasts, future bombing missions, harbor defenses, Chemical Warfare, Infantry, Armored Force, Artillery, and other operations; and for the spreading network of weather stations needed for expanding global war. To meet these needs, the experienced facilities of only one company were initially available.

While the first production was rolling, SCEL began a concerted development program of modern meteorological equipment to produce efficiently performing and up-to-date radiosondes, plotting devices, aerographs, and wind, automatic surface observation, pressure measuring, ceiling light projector equipments, and others. Concurrently with the production of these newly-designed devices, a training program was organized and conducted at the Signal Corps Laboratories to instruct Army personnel in their operation and maintenance.

Simultaneously the design, range and accuracy of radiosonde transmitters and receivers was improved. Particularly, airborne radiosondes were made lighter and smaller, and development pressed to 400, and later to 1725 megacycles. Radio Set SCR-658, operating on 400 mcs, was first placed in production in the war's approximate midpoint and used by AAF for both B-29 raids upon Japan and for world-wide ATC operations. It was in addition employed by the Field Artillery for ballistic correction of artillery fire.

Production shortages however soon harassed meteorological production lines which by dint of great industrial accomplishments had been expanded many times. Critical latex shortages for radiosonde balloons for instance cut sharply into delivery of the demand from all services, which was climbing to 500,000 units a year. A concentrated effort to develop substitutes produced neoprene substitutions which actually gave superior performance to the long accepted latex. Hydrogen, used to inflate these balloons, was another problem: commercial 130-lb. high-pressure cylinders which weather stations exhausted at the rate of three a day, set up a major transportation log-jam, broken by the development of portable low-pressure hydrogen generators.

Additional meteorological needs are being answered by the development of instruments launched from aircraft to explore the atmosphere below the plane, providing both meteorological sounding and data on the ceiling over a field prior to landing. Others installed in aircraft recorded meteorological parameters during ascent or descent; one model providing data during ascent, descent and over the flight path for a period of twelve hours, later the basis of establishment of Air Weather Reconnaissance Squadrons by AAF. Further meteorological equipment developments were Aerograph AN/AMQ-2, a primary standard for temperature and humidity measurement from high-speed aircraft, Psychrometer ML-313/AM; Strut thermometer ML-353/AM; and the AN/AMQ-1, AN/FMG-2, AN/GMQ-1 and others.

Other developments widely known in the meteorological field were transportable mobile weather stations extending the main weather network, permitting the establishment of forecasting and flight control stations within 24 to 48 hours after the initial landings in many operations during the war.

In addition was the experimental design of two types of automatic weather stations, furnishing meteorological measurements over extended intervals of unattended operation. One type was designed to be dropped from an aircraft behind enemy lines or over ocean areas, serving as a radio weather beacon over a period of a week for reconnaissance planes flying over the area; another, intended for isolated regions, for instance the Arctic and remote islands—an unmanned robot weather station in itself.

(Part II, in the March-April issue of SIGNALS, *will examine further fields, and the Signal Corps' present program of concerted, long-range research.)*

By COLONEL JULIAN Z. MILLAR
Radio Research Engineer, Western Union Telegraph Co.

Telegrams on the beam

A preview of the Western Union System of Radio Beam Telegraphy

KEEPING pace with post-war technology and putting electronic wings on telegrams, Western Union plans to establish ultra-high-frequency radio systems between the major cities in the United States during the next seven years. These radio systems, over which telegrams are to be transmitted, ultimately may replace the trunk pole lines with their hundreds of thousands of miles of wire in the present telegraph network.

Western Union assisted in the construction of an experimental radio-relay circuit between New York and Philadelphia in the Spring of 1945 in cooperation with the Radio Corporation of America, and with the approval of the Federal Communications Commission. This venture was successful and proved conclusively that radio-relay telegraph transmission, which we like to call Radio Beam Telegraphy, is both feasible and economical.

The Company has now received FCC licenses to establish a triangular radio system connecting three cities: New York, Washington, and Pittsburgh; and for a second circuit between New York and Philadelphia. Factory production of equipment is in process and upon installation, telegrams will begin to flow over these new facilities, experimentally, pending authority from the Commission for permanent commercial operation.

Carrier Systems

In 1917, Western Union became interested in carrier telegraphy, which was then called "an alternating-current system of telegraphy." However, it was not until 1927, after vacuum tubes became available, that the first practical system was ready. The advantages of carrier systems are many. Stated simply, it is possible to derive more telegraph channels from a given number of wires, and these channels are superior to those obtainable from direct current systems of the grounded-wire type. These improvements are the result of several factors, an important one being the use of paired wires.

Carrier circuits remain susceptible to physical damage to the wire lines, and in fact require a higher type of maintenance, but the electrical performance of the system is much superior. The use of transposition systems and balanced input to the equipment were contributory improvements, resulting in a large reduction of the interference induced in the line.

Advances in equipment performance kept pace with developing transmission possibilities, and in 1937, Western Union's frequency-modulated system for telegraph carrier was placed in operation. A frequency-modulated system provides a telegraph

channel less subject to interference effects because of the FM-noise improvement, and it also eliminates telegraphic distortion formerly caused by attenuation variations in the lines. By FM telegraph carrier methods, the quality of signal transmission has been improved to the point where it is possible to transmit over circuits several thousand miles in length without using regenerative telegraph repeaters at the points of interconnection.

Channel Division

Figure 1 shows the method used for dividing voice bands, similar in frequency response to a telephone circuit, into telegraph carrier channels. Any voice band may be filled with a choice of three different types of telegraph carrier channels, or it may be used for Telefax service, or as a telephone circuit. The teleprinter channels are spaced 150 cycles and make use of center frequencies ranging from 525 cycles to 1575 cycles in the basic group. A similar group is translated to a higher position within the voice band by heterodyning the group against a frequency of 3600 cycles. This avoids the design of additional equipment. All of these narrow carrier channels are deviated plus and minus 35 cycles by the telegraphic signals. Sixteen independent teleprinter systems can be operated in a single voice band.

Eight Multiplex or Varioplex circuits may be obtained from one voice band. These wide carrier channels are spaced 300

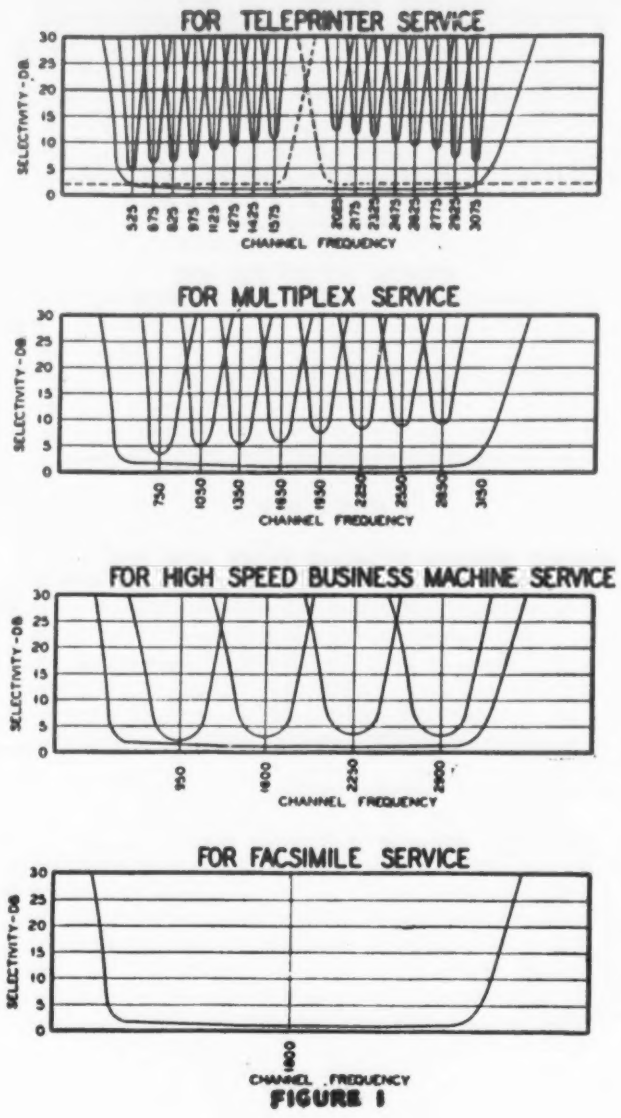


FIGURE 1

cycles and make use of center frequencies ranging from 750 cycles to 2850 cycles, which are deviated plus and minus 70 cycles. These channels are also used for high-speed ticker interconnection.

Four channels suitable for interconnection of business machines may be obtained from a voice band. These channels will be spaced 650 cycles apart and the center frequencies will be 950, 1600, 2250, and 2900 cycles.

The facsimile and telephone circuits require an entire voice band, or approximately 2600 cycles of spectrum.

Radio and W. U.

In 1920, Western Union began investigations leading to the possible commercial use of radio in the handling of telegrams. Notwithstanding rapid developments, the domestic telegraph industry has never made commercial use of radio transmission, except for emergency purposes when wire lines were interrupted.

This policy was maintained until 1940, because no radio system had been visualized which could compare with a pair of copper wires between two points on an overland route. Radio transmission was considered most useful for broadcast dissemination, for mobile services, and for intercontinental communication.

While ultra-short-wave developments in the early 1940's seemed most promising, prior to that time it could not be said that radio was as economical as a wire line or that it could provide the necessary degree of circuit stability and continuity of operation.

Another factor in this situation was the frequency shortage which existed. The number of channels which would be required to transmit the inter-city trunk load of Western Union (950,000,000 messages annually) would be quite impossible to secure by allocation from the Federal Communications Commission because of the demands of many other necessary services, for some of which the use of radio is unavoidable.

In 1945 the situation was very different. At that time, as a result of more than four years of

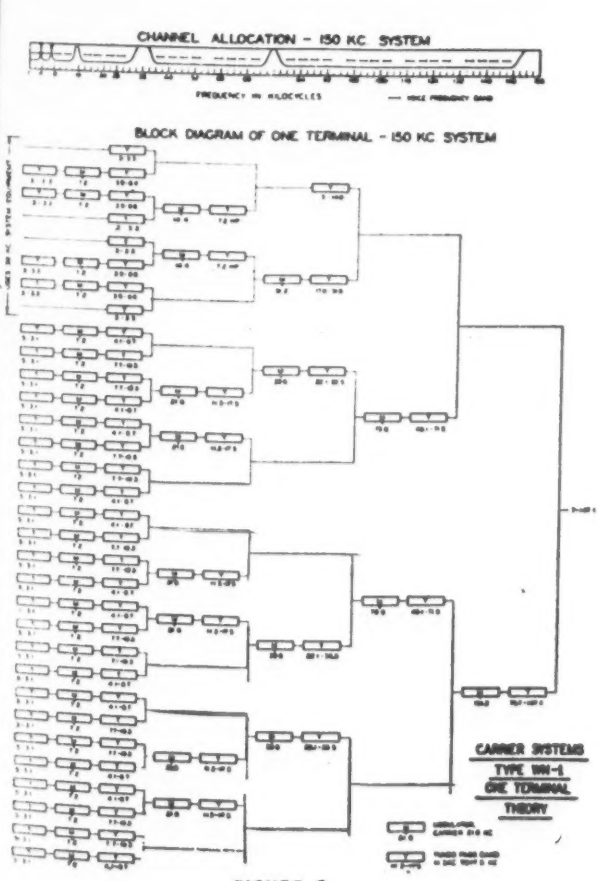
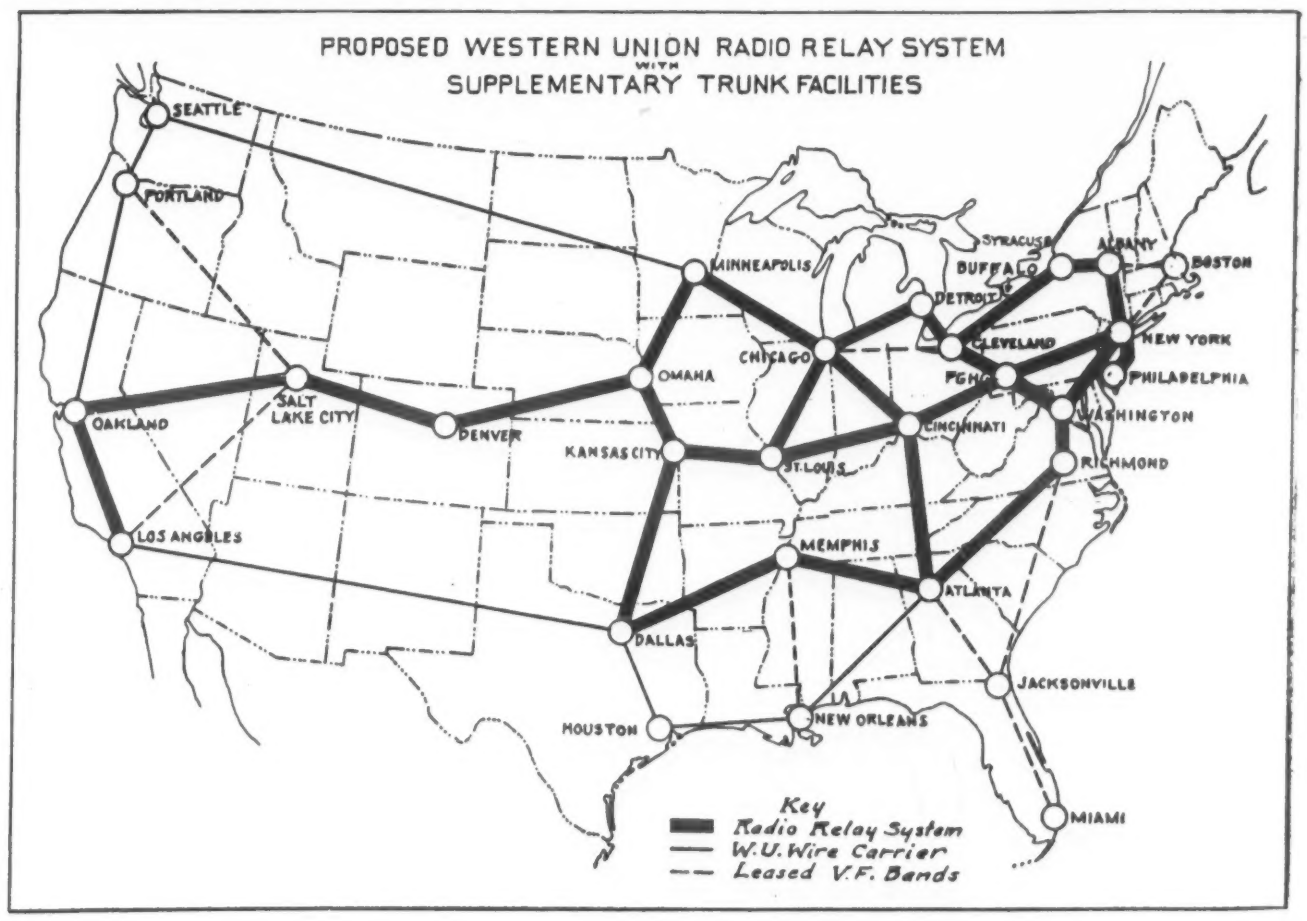


FIGURE 2



New York antenna installation.

intensive war research, it became apparent that the application of super-high-frequency radio to telegraph transmission was not only feasible, but very practical. The progress made by hundreds of scientists working on radar and communication systems, the perfection of micro-wave techniques including wave guides and cavities, the development of new tubes such as the resonant cavity magnetron and the Klystron, and contributory effort in allied fields, all gave tremendous impetus to the new art. This new era is characterized by a change in terminology—the "old timer" feels himself lost in a sea of unfamiliar expressions and nicknames for new devices.

The Microwaves

Today, the useful radio frequencies have been pushed higher by a factor of 100, and a frequency of 30,000 megacycles can be controlled by the radio engineer with almost complete knowledge of behavior. At such a frequency the wavelength is only 1 centimeter, which approaches that of infra-red radiations. Micro-waves are ordinary radio waves, except for the extreme shortness of wavelength, and are the same kind of vibrations as those of light. Therefore, it is possible to work with microwaves in the same manner as with light, if proper dimensional allowances are made. There are no discontinuities to be expected insofar as the equipment is concerned as the wavelength is shortened.

It may not be obvious that the small size of the wave is such a valuable asset, but it is this property which permits the use of highly directive antennas, some of which make use of wave guides and horns, dipoles and parabolic reflectors. By combining the known techniques, a microwave beam of almost any desired shape and sharpness may be generated and projected to a distant point where a similar antenna is used to gather energy from only one direction.

This ability to concentrate energy results in tremendous saving of power. For instance, with antennas only four feet in diameter, a power gain of 30 decibels may be realized, and 1 watt will be as effective as 1000 kilowatts in a non-directional system. Such high directivity is also useful in preventing interference. Furthermore, the same frequency can be utilized for transmission or reception as many as eight times at one location, or once for every 45° of azimuth angle. The perfection of a wave guide of special configuration, which is known as a radio frequency hybrid, permits the use of a single antenna for both transmission and reception if the frequency separation is in the order of 100 megacycles, or even on the same frequency if the application does not require too high an amplification in the receiver. And if it is desired to direct transmission to a moving object, a ship or an aircraft, this can be done with great facility, at the same time insuring a relative secrecy in the transmission.

Another property of microwaves is that they are propagated in the troposphere in accordance with optical laws. They penetrate into, and perhaps through, the ionosphere and are not reflected by it. Hence, microwaves are not useful for long-distance transmission, and in this particular they differ from ordinary short waves. Because microwave transmission does not depend upon reflection from the ionosphere, variations in the ionic density of the various layers of this medium have no effect upon transmission. It is not necessary to choose different frequencies for day or night operation, or for some particular distance.

Microwaves are free from the devastating effects of sun spots and are divorced from such a fickle medium as the ionosphere. Ample proof of this fortunate circumstance was obtained recently when a severe disturbance of short-wave radio and grounded wire communication resulted from unusual sun-spot activity, while the microwave system continued to function normally.

The Shortest Distance

Microwaves travel in straight

lines, except for some bending due to atmospheric density effects. Therefore, these waves do not follow the curvature of the earth, but disappear into space where they create no harmful interference. At first, this might seem to be a disadvantage, since the distance range is limited to relatively short distances, but the ability to use the same frequency assignment again and again in areas separated by approximately a hundred miles is a most fortunate circumstance.

Another inducement is the enormous size of the micro-wave spectrum available for exploitation. We now have more than 100 times the frequency band width previously available, and therefore it is possible to consider the assignment of a reasonably large signalling spectrum to each radio channel. If properly allocated, the necessarily large number of telegraph channels can be provided, and the door is opened to the development of wide band systems which are economically attractive as compared to a wire line, or a coaxial cable with repeaters. Radio relaying holds great promise as a means of network broadcasting of television programs.

At micro-wave frequencies, atmospherics do not exist, and any radio interference must come from a local and not a distant source. A very simple portable direction finder is all that is required to discover the location of an interfering signal.

There are several additional advantages of a micro-wave relay system as compared to a wire line. The initial cost and the annual expense of operation are believed to be less, if a large number of telegraph channels are derived from the radio system. The quality of transmission is improved. Very little time is required to install new equipment, or relocate an existing system, and if a change in plan is necessary, most of the equipment is salvageable. Maintenance operations are concentrated at a few relay points instead of being distributed along the line. The loss of time due to physical damage to the equipment resulting from storms will undoubtedly be less. Construction difficulties over bodies of water, mountains, deserts, and in jungles are reduced. And finally, there is a tremendous reserve of circuit capacity, which can accommodate new services because of the cheapness of band width, and which can provide for 100% alternate route or fallback protection in the event that a direct circuit between two cities is interrupted.

Equipment

For the first phase of experimental operation, existing types of wire line voice-band translation equipment and carrier terminals will be utilized to transmit commercial telegrams. The Type G voice-band translation equipment rearranged for 4-wire operation, and thus supplying eight voice bands, will be manufactured by the Federal Telephone & Radio Corporation. The telegraph channel terminals will be manufactured by the Philco Corporation. Western Union specifications are being followed by these two firms in the production of the equipment.

Western Union engineers have undertaken the development and design of new voice-band translation equipment which is necessary to adapt radio operation to telegraph usage. This work is progressing in the Western Union laboratories at the present time and only a general description is included here. Figure 2 is a block diagram of the modulator and tuner arrangement to be employed to derive 32 voice bands from each radio circuit. Each voice band may be used for telegraphy in both directions simultaneously.

Western Union engineers have also been responsible for the design of steel towers which will be used at all of the relay points; for the buildings which will be used at each of the relay stations and at some of the terminals; and for the design of the emergency power equipment which will be used at relay stations.

The Plant Department has prepared trial profiles from which the station sites were located. This group has also arranged for the leasing of space in high city buildings suitable for the installation of the terminal radio equipment, and for the purchase of land upon which the repeater stations are being built. The Plant Department is also responsible for construction activities. The Plant Engineer has contributed to the overall planning, especially in the preparation of cost estimates.

The Traffic Department has been responsible for the assignment of the carrier circuits which will be derived from the various radio systems. This department also selects the number of teleprinter channels, the number of Multiplex channels, and the number of Telefax channels which will be operated between any two functional offices. Not all of the available telegraph channels will be permanently assigned—at least 50% will be held in reserve for emergencies, and to provide alternate routes in the event of a circuit interruption.

Frequencies

The Federal Communications Commission has allocated a number of frequencies ranging from 1760 mc. to 30,000 mc. for radio relay use. Western Union has accomplished most of its transmission in the 4,000 mc. band, but simultaneous propagation tests have been carried out in the 2,000, 4,000, 6,000 and 9,000 mc. bands.

The radio equipment has been developed by the Victor Division of the Radio Corporation of America, at Camden, N. J., with Western Union engineers cooperating during the past year of joint experiments by offering suggestions, by outlining requirements, in overall testing, and in providing suitable arrangements at the

This Western Union experimental tower is at Bordentown, N. J.

terminals, including carrier circuits, housing and power.

Modulation

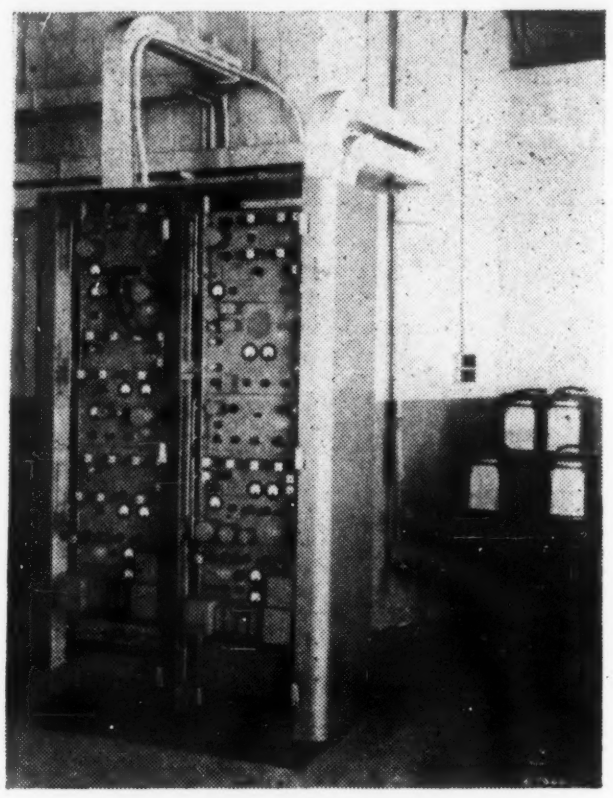
One of the most important decisions to be made in designing a radio relay system suitable for telegraphy is the choice of a modulation method. In the RCA equipment, frequency modulation has been selected, as this type of modulation meets the requirements of a broad-band system much better than amplitude modulation. However, in the Thompson system of frequency modulation, not only is the final radio frequency carrier frequency modulated, but a sub-carrier is employed, and this sub-carrier is also frequency modulated, as will be explained below.

The final radio frequency carrier, located in the center of the assigned frequency band of the station, will be simultaneously frequency modulated by two groups of input signals. The first group is comprised of a 1-megacycle sub-carrier and its associated side-band. The peak amplitude is adjusted so that a 2-megacycle deviation is produced in the output frequency. The 1-megacycle sub-carrier is frequency modulated by the output of the Western Union voice-band translation equipment and has an average deviation of 200 kilocycles, with an occasional peak deviation of 400 kilocycles. This group of input frequencies has been termed the signalling channel, and it is available only at the terminals of the system.

The method adopted for subdividing the signalling channel into usable voice bands is the same as the one employed for wire line operation, except that it will be a much larger system, and supplies 32 voice bands, each 500 cycles to 3,100 cycles wide. This requires a frequency spectrum extending from 500 cycles to 150,000 cycles. As in the case of wire line operation, any one of the voice bands may be utilized as a telephone or facsimile circuit, or further sub-divided into the various types of telegraph carrier channels.

The second group of input signals corresponds to those frequencies comprising service modulations, which will consist of a telephone channel for technical conversations between terminals and the relay stations. The telephone channel may be used to transmit certain test-tone frequencies which will be used to indicate conditions of operation and for a remote monitoring method. The peak amplitude of service modulation will produce a 100-kilocycle deviation of the final radio carrier. The service channel is available at all stations, and can be used without interference to the signalling channel.

The radio system has been designed to give a normal signal-to-noise ratio of 50 db. in each of the derived voice bands, consideration having been given to the possible employment of the various types of telegraph service



Terminal set at Manhattan station.

in any combination. Actually, experimental results have been superior to the design value. In a frequency-modulated system, the signal-to-noise ratio depends upon such factors as the deviation, the band width of the receiver and its internal noise, and the amplitude of the signal at the receiver input, the latter being affected by the transmitter power, the net gain of the transmitting and receiving antennas including connections thereto, and the attenuation and fading characteristics of the propagation path. Experimental results on the New York-Philadelphia system indicate that the required signal-to-noise ratio can be obtained with a transmitter power of 50 milliwatts. The signalling channel is pre-emphasized, with corresponding correction applied at the receiver, to insure that the noise is equally divided between the derived voice bands.

RCA System

The channel band width of the RCA system is of interest. When the frequency modulated sub-carrier is applied to the final radio-frequency carrier as a frequency modulation, the result is a number of upper and lower side-bands spaced 1 mc. apart, and a multitude of smaller side-bands which lie on either side of the principal side-bands. It is necessary to receive only the first and second order side-band groups on either side of the final carrier, the amplitude of the third and higher order side-bands being important only in considering adjacent channel interference. Therefore, a channel band width of 6 megacycles should be allowed for each transmitted carrier with its essential modulation to protect the adjacent channels, although only a four-megacycle receiver band width is required.

Only a few assigned frequency channels will serve a large area, because they can be used repeatedly. It is believed that eight frequency groups will provide one radio beam telegraph system between each of the larger cities of the United States. As to which frequency band will be most dependable, the results of further experiments must be awaited.

It was anticipated that, in a micro-wave system, the received signal would be subject to certain variations. At a wave-length of less than 1 cm., the frequency is high enough for molecular phenomena to be an influence. Selective absorption of energy by the oxygen and water vapor in the atmosphere produces an attenuation, but at a wave-length longer than 1 cm., this is a minor effect, the average attenuation being in the order of 0.05 db. per mile. During a rainstorm, there is another type of absorption, depending upon the wave-length of operation and the density of rainfall, but in this effect, for a wave-length greater than 5 cm., is not very serious. Furthermore, a heavy rain usually occurs over a distance of only a few miles at one time. At 1 cm., a heavy rainfall can produce an attenuation as high as 35 db. per mile.

Micro-wave Diversity

In the latter part of June 1945, a much more serious effect was first observed. On a still night, between the hours of midnight

and dawn, and especially during the periods of high humidity, signal fading became severe. Increased transmitter power was found ineffective in keeping the signal above the minimum required value. It was soon discovered that the receiving antenna was located in a local field of complex nature, and that the signal in another antenna placed about 50 feet lower than the first would be strong when the signal in the higher antenna was weak. Therefore, vertical diversity reception was indicated, and will be employed on the next equipment installed, thus limiting total fading to approximately 15 db. per section.

At the terminal receiver, two intermediate frequency amplifiers are employed, both with limiters and discriminators. The 1-megacycle subcarrier is re-established at the output of the first amplifier-discriminator combination, fed into the second, limited, detected, and after amplification, is connected to the voice-band translation equipment. Thus, in the terminal equipments, distortion is held to a very low value.

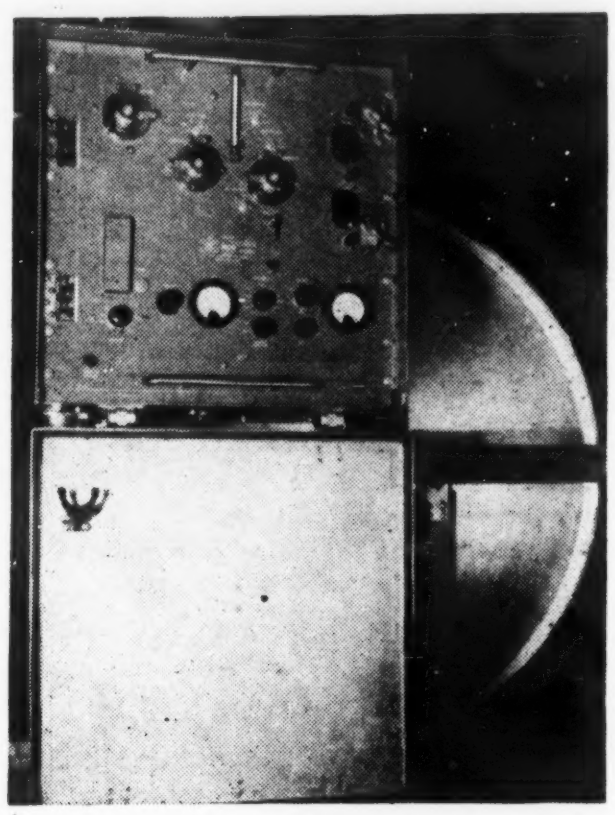
At the repeater stations, a different method is followed; only one intermediate frequency amplifier is employed. The output of this amplifier-discriminator combination is, of course, the 1-megacycle sub-carrier, and this sub-carrier is connected to the input of the forwarding transmitter directly, instead of being demodulated. The measured overall distortion of such a repeater is extremely low. Until the factory-produced equipment is installed and tested the exact distortion values will not be available, but it is believed that the overall distortion on a 300-mile system can be held to less than a tenth of one per cent.

Repeater Stations

The layout of the repeater sections presents an interesting problem. An examination of the capabilities of the radio equipment shows that with presently available tubes, a maximum repeater separation of approximately 55 miles is feasible. It is obvious that the topography of the land will have a most important bearing. Towers of different heights may be employed. And a good repeater location will be near a heavy commercial power line and accessible from well-traveled roads.

The repeater or relay stations for the New York-Philadelphia system were initially located at Ten Mile Run, just south of New Brunswick, N. J., and Bordentown, N. J. Recently it has been found that there was an obstruction in the New York to Ten Mile Run section, and it will be necessary to add a third relay station at Woodbridge, N. J.

In the interests of universality, it was decided to standardize on steel towers of different heights, all with the same size apparatus cabin on top. This cabin will be 12 feet square, and 9 feet high.



Microwave receiver equipment cabinet.

The side walls are removable, to permit substitution of windows which will probably be made of impregnated fire-glass cloth, and which will be protected mechanically against the accumulation of ice and snow. The cabin is large enough to accommodate the four high frequency oscillator cabinets required for each of two complete radio relay equipments, although initially, only one circuit will be repeatered at many of the towers.

It is planned to operate the relay stations on an unattended basis. Maintenance personnel will be stationed at the terminals and suitable fault locating equipment will be provided for determining the location of any station in trouble.

Sites

The Washington, D. C., terminal building will be erected at 41st and Wisconsin Avenue. The new building will contain not only the radio equipment, but also the voice-band translation equipment. The Western Union main office, about six miles away, will contain the telegraph channel terminals and lead-covered cables will be used to conduct the voice-bands between the two buildings.

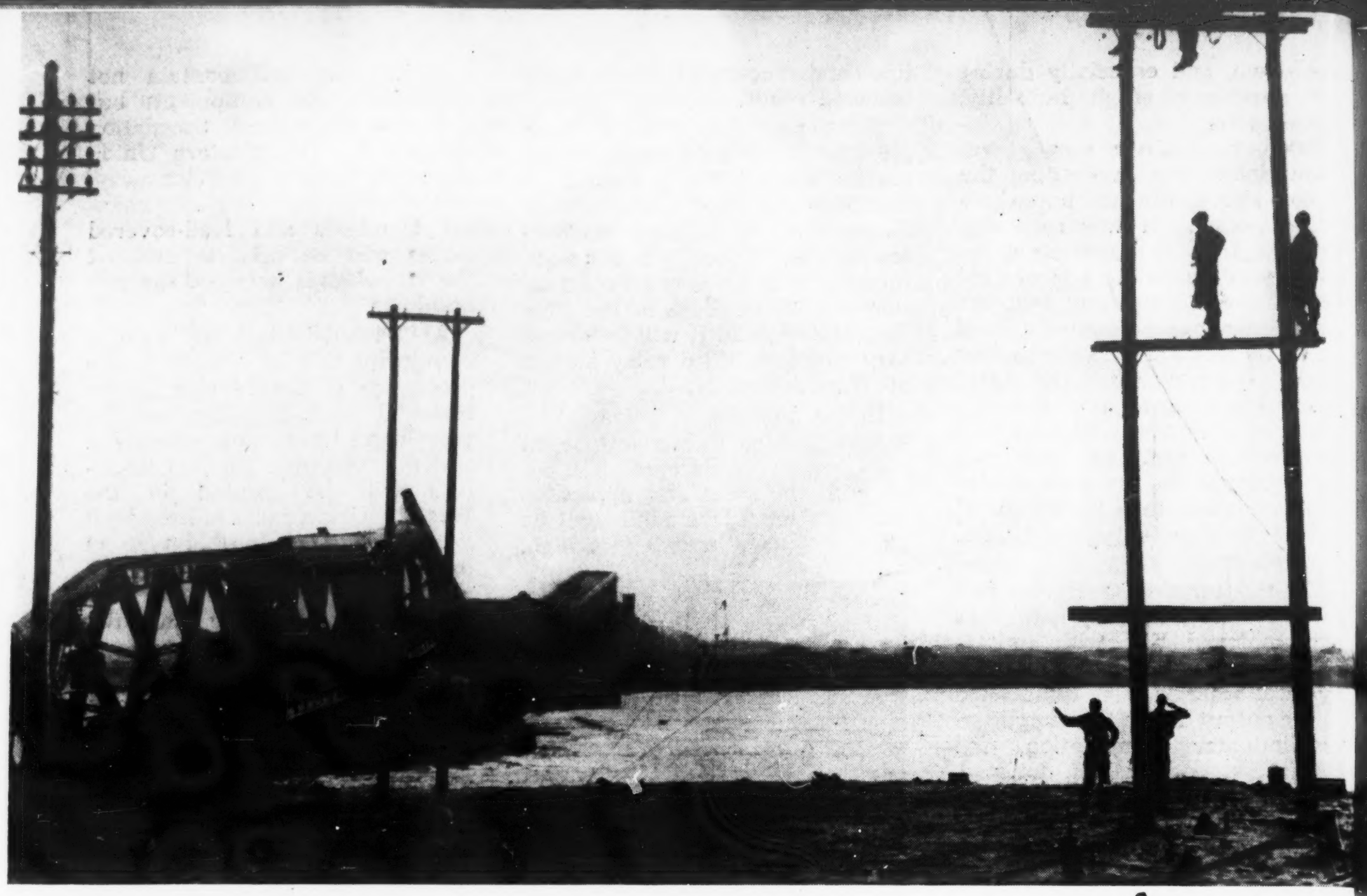
At Philadelphia, the radio equipment will be located in the penthouse of the Market Street National Bank Building, but the voice-band translation equipment and the telegraph channel terminals will be located in the Western Union main office, about a mile distant. In this type of installation, coaxial cables will connect the two locations, and these cables will carry the entire signalling channel, 500 cycles to 150 kilocycles.

At Pittsburgh and New York, all of the equipment will be located at the Western Union main offices but, in the case of the Pittsburgh installation, a very short radio relay link, only three miles long, will be employed as the last section.

Extensions of Western Union's radio operations are planned generally in the form of triangular relay systems which eventually will interconnect all major cities in the United States. The next system projected for installation will connect Chicago and Pittsburgh via two routes, one through Cincinnati and the other through Cleveland and Detroit, thus establishing the second major triangle. Another system between New York and Cleveland via Albany and Buffalo is also being planned.

Another field of application is for railway communications. Television relaying and communications with airplanes, or other moving craft, have already been mentioned. An example of this latter type of telegraph transmission, in which there is great interest at the present time, is the local delivery of telegrams. By placing a transmitter in the Western Union's main office, and a receiver in a delivery vehicle, continuous contact can be maintained, which will speed up the delivery of the message and avoid much unnecessary driving.

Courtesy: "Journal of the Franklin Institute."



Spanning the Rhine with open-wire cables.

Signal Planning For The Invasion

By Brig. Gen. Francis H. Lanahan, Jr.

Chief Signal Officer, European Theater

In April 1943, a small combined British and U. S. staff was formally established at London's historic Norfolk House, in St. James Square, charged with the responsibility of formulating the basic plan for the most stupendous military operation in history: the invasion of the European continent.

This select group, in whose hands lay the ultimate fate of the greater part of the world's population, became COSSAC, derived from Chief of Staff, Supreme Allied Commander (designate). The Signal component of this staff was organized in August and September 1943 with the task of planning, coordinating and directing the communication system required for the cross-channel operation, designated "OVERLORD." It was further charged with Signal plans for certain alternatives in the event that the Germans withdrew or capitulated prior to the launching of the main operation.

COSSAC later became SHAEF, Supreme Headquarters, Allied Expeditionary Force. The formation and operation of the Signal Staff, which functioned with both bodies, is an interesting study in inter-Allied cooperation.

Plans and Preparation

The initial component of the Signal Division found that much preliminary communication planning for an invasion had been done by the British Admiralty, the War Office, Air Ministry, General Post Office, ETOUSA (European Theater of Operations, U. S. A.), and the Commander of Naval Forces in Europe (COMNAVEU).

Planning and execution had progressed sufficiently to cover the major utilization of the communication facilities within the United Kingdom for the mounting phase of Operation OVERLORD; the selection and construction of suitable combined communication posts along the southern coast of England; the selection and construction of wireless sites on the southern coast; and the preparation and the provision of equipment for the extension of the wire system across the channel by means of submarine cables and very-high-frequency radio links. In addition, the ministries and Headquarters, ETOUSA, had drawn general plans covering the provision of Signal personnel and equipment for an invasion. All that remained was to meet the

requirements of the particular operation envisaged in the OVERLORD plan.

Similarly, it was discovered that the British and American intelligence agencies had accumulated, over the previous years, almost complete information of existing communication facilities on the European continent. Possession of this knowledge was to prove invaluable in the rapid integration of operating systems in a fluid tactical situation that altered almost hourly.

Previous arrangements had also outlined the responsibility for supply of the various Army, Air and Naval components of the force as a function of the appropriate ministries for the British elements, and of Headquarters, ETOUSA, COMNAVEU, and the U. S. Air Force for the American components.

The decision on the structure of command provided initially a Supreme Commander for over-all coordination and direction, and subordinate commanders for the combined Army, Air and Naval units.

Responsibility for the detailed planning for communications for the assault phase of the Operation was delegated to the Commanding General of the Ground Force, the Admiral-in-Chief of the Naval Task Forces, and the Commanding Generals of the Tactical Air Forces. Much of the coordination required for communications for the assault phase of the operation was effected through the Combined Signal Board under the Signal Officer-in-Chief, 21st Army Group, and by direct action by the Signal Staffs of the several commanders.

Formation of Signal Staff

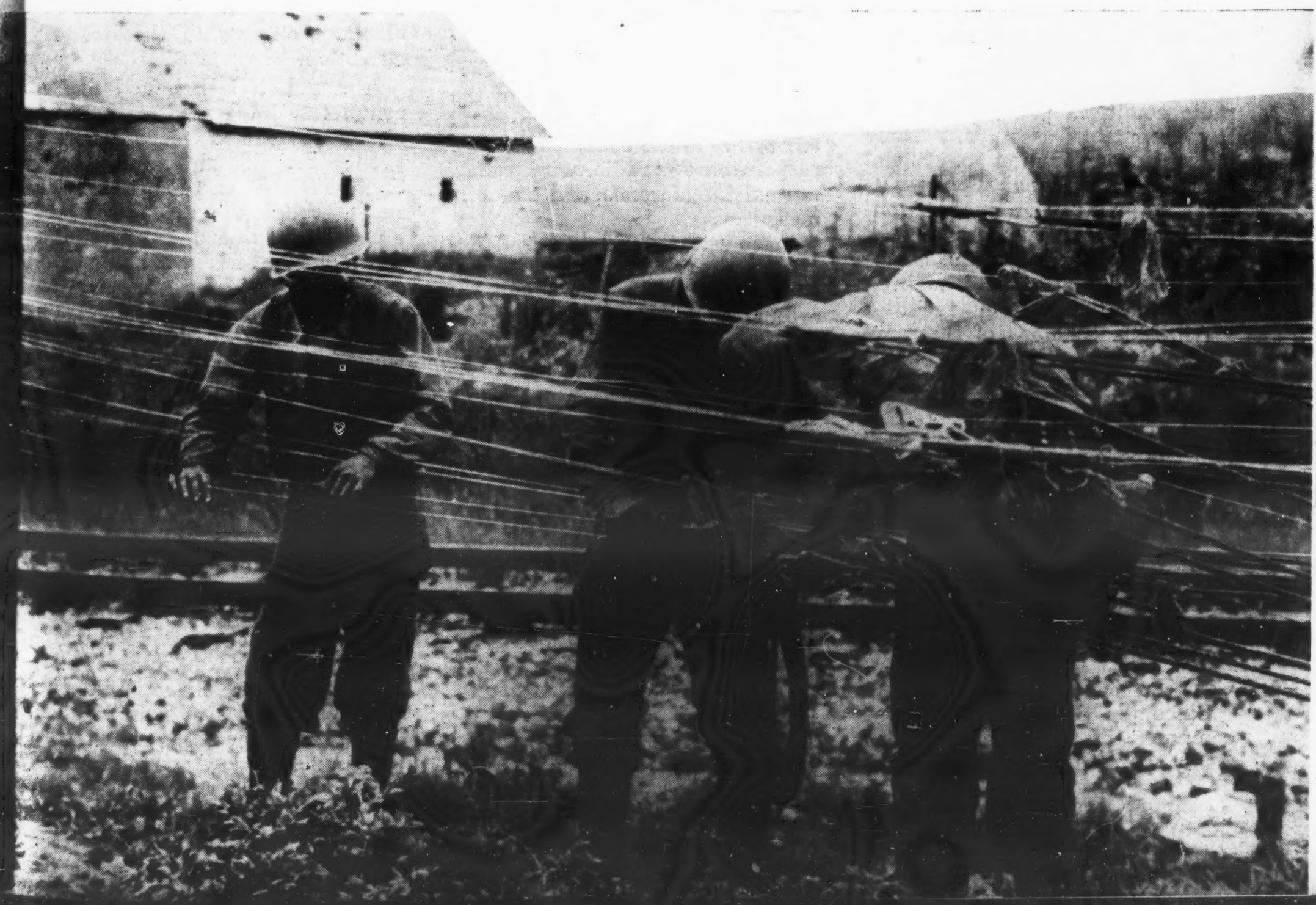
On the basis of preparatory accomplishments within the United Kingdom, and the proposed organization for command, a study was initiated to determine the appropriate staff for the Signal Division, SHAEF, required to accomplish the mission of over-all planning, coordination and direction of the Signal system for the invasion.

The study indicated that the major problems confronting the Signal Division would be as follows:

Additions or adjustments in the existing networks in the United Kingdom;
Completion of the planning and projects for cross-channel cables and radio links;
Planning the continental networks in accordance with strategical and tactical plans;
Allocation of radio frequencies;
Clearance of radio interference;
Offensive and defensive Signal countermeasures;
Common communication procedures;
Codes and ciphers;
Coordination of Signal supply when of combined interest;
Coordination of Signal operational training;
Communication for the press, Psychological Warfare and other contributing services;
Messenger services by air, boat, train and motor; and
Communications required for Supreme Headquarters.

Based on the projected task and prior accomplishments by other agencies, a study was made of the best possible type of organization to accomplish the mission of the Signal Division. Three alternatives emerged from this study. First, a Signal Division consisting of six separate sections, one for each of the U. S. Army, British Army, U. S. Navy, Royal Navy, U. S. Air Force and British Royal Air Force; second, a Division consisting of a com-

Linemen at work near Lithaiel, France.



bined integrated staff composed of personnel representing all of the British and American services; third, one consisting of an integrated staff of British and U. S. Army officers closely allied with the Signal staffs of the senior Air and Naval Commanders.

From a purely Signal aspect the second alternative was, in all probability, the most desirable. However, the overall command structure dictated that the senior Air and Naval Commanders must have the most highly competent Signal staffs. Both the first and second alternatives would, therefore, require duplication in Signal staff personnel. Because of the scarcity of highly trained Signal planning officers, these two alternatives were rejected in favor of the third plan, which provided a Signal Division consisting of an integrated staff of British and American Army officers, closely allied with the Signal staffs of the senior Air and Naval Commanders through the Combined Signals Board.

On this decision, the Signal Division was organized with a Plans and Operations Section responsible for plans, operational orders and instructions, information and data, and the maintenance of liaison with other interested military and civil agencies; a Telecommunication Section responsible for radio, radar, Signal traffic, Signal procedure, wire lines, security and Signal radio countermeasure matters; a Requirements Section responsible for the coordination of Signal personnel and Signal supply matters requiring combined attention; the Headquarters Signal Officer responsible for the establishment, operation and maintenance of the Signal facilities serving the echelons of Supreme Headquarters and for the operational direction of the Signal units assigned to SHAEF; and, finally, an Administrative Section responsible for administrative matters within the Signal Section.

Had the Signal planning for the assault phase and the responsibility for supply been centralized at Supreme Headquarters, the staff required would have been several times as large.

Combined Signal Board

Since the Signal Division was composed of U. S. and British Army personnel only and contained no representatives of the Allied Navies or Air Forces, an important agency was organized under the title: Combined Signal Board, COSSAC. This Board was composed of the Senior Signal Officers of the Allied Navy, Army and Air Force Commanders and was under the chairmanship of the Chief Signal Officer, COSSAC. It was designed to obtain high level coordination in Signal matters, necessary among the Air, Navy and Ground elements, particularly in the fields of wireless frequency allocation, inter-service and hostile radio interference and the allocation of wire facilities. The Board was served by a number of sub-committees composed of appropriate section chiefs of Signal Division, SHAEF, and of the subordinate Naval, Army and Air staffs. These committees were responsible for radio, wire, radar, mutual interference, and countermeasures.

Pulling lead wire over stream in Germany.

From the several hundred decisions of the Combined Signal Board bearing on policy and coordination for the operation, the following have been selected as indicative of the scope and importance of its functions:

a. Arranged for the entire Theater of Operations to be placed on a common time basis and that all elements involved in the operation would employ a uniform method of expressing time in messages and orders;

b. Placed in effect, within the Ground Force, single-call procedure;

c. Allocated radio frequencies to all forces engaged in the operation, a problem of tremendous magnitude and difficulty;

d. Established a system of priority for telephone traffic, necessary because of the inadequate wire facilities, an ubiquitous problem during fast moving operations;

e. Allocated cross-channel cable and VHF circuits, and completed the planning commenced on this project by the British services sub-committee prior to July 1943;

f. Established a system and organization for the clearing of mutual radio interference and for dealing with interference from sources outside the control of the operation; and

g. Provided priorities for the restoration of circuits within the United Kingdom in the event of damage by enemy bombing, based on the relative importance of these circuits to the over-all operation.

Although it is believed that a completely integrated staff would have provided a more efficient agency for Signal planning, the Signal Divisions of the service staffs, coupled with the Combined Signal Board, did present a satisfactory and workable arrangement. This organization might be used as a model on which to base an agency in the United States to institute better coordination among governmental bureaus and commercial groups interested in international and domestic communications.

While the Board consisted of carefully selected communication officers of the six services represented, the outstanding characteristic of the body was a spirit of cooperation and a willingness to compromise. There were numerous differences of opinion, frequently rather sharp, but the members rarely lost sight of their long range objective, which was to provide the best possible com-

Snow was no deterrent to maintenance, Belgium.

munications for all of the commanders, regardless of which service had to sacrifice some of its favored methods or facilities.

Communication Across the Channel

Communications for an assault on a coastline, when commanders are on the near shore, then afloat, and later on the far shore, will always present a difficult and intricate problem. Much time and effort was devoted by all staffs to the provision of communications for this phase of the operation. While afloat, the commanders were provided with headquarters ships equipped with radio and numerous other means of communications, as well as radar for protection. In general, the organization of the nets was similar to that employed in numerous other amphibious operations.

One of the most interesting features of the OVERLORD operation was the rapidity with which the wire network in the United Kingdom was connected to that on the Continent by cross-channel cables and VHF radio links. Much credit must be given to our British associates for their early and vigorous planning for such inter-connections and for the energy with which they attacked the problem of providing the means. These steps were taken long before the Signal Staff of SHAEF was organized. The major responsibility which fell to SHAEF was to decide the location of the far terminals, and to allocate equitably among the services the telephone and telegraph channels in the connecting submarine cables and the multi-channel VHF radio links.

Continental Wire Network

Considerable data on the nature of civil and military line communication systems on the Continent were made available to the Signal Division by the various Allied intelligence agencies. This information was released in appropriate form for use by lower units. Accompanying instructions indicated which land-wire cables and wire lines would be developed in first priority and set forth the allocation in priority of the circuits obtained by rehabilitation or new construction. These instructions were, of course, coordinated with the planned scheme of maneuver and the projected locations of the major headquarters. A boundary setting forth construction responsibility was established between the British forces on the east and the north and the American forces to the west and the south.

A study was made of the probable wire stores required for the rehabilitation of the existing network and for the construction of new facilities to determine whether the quantities of British and American supplies, previously ordered, were adequate for the project. It was discovered that a more extensive carrier-telephone system would be required in the American Zone and the necessary action was initiated to obtain equipment. A long range study was made to estimate the wire stores required between the initial period (D-Day to D plus 90) and D-Day plus 240, in order to insure that somewhat reasonable demands were being placed on the supply ministries and on the War Department.

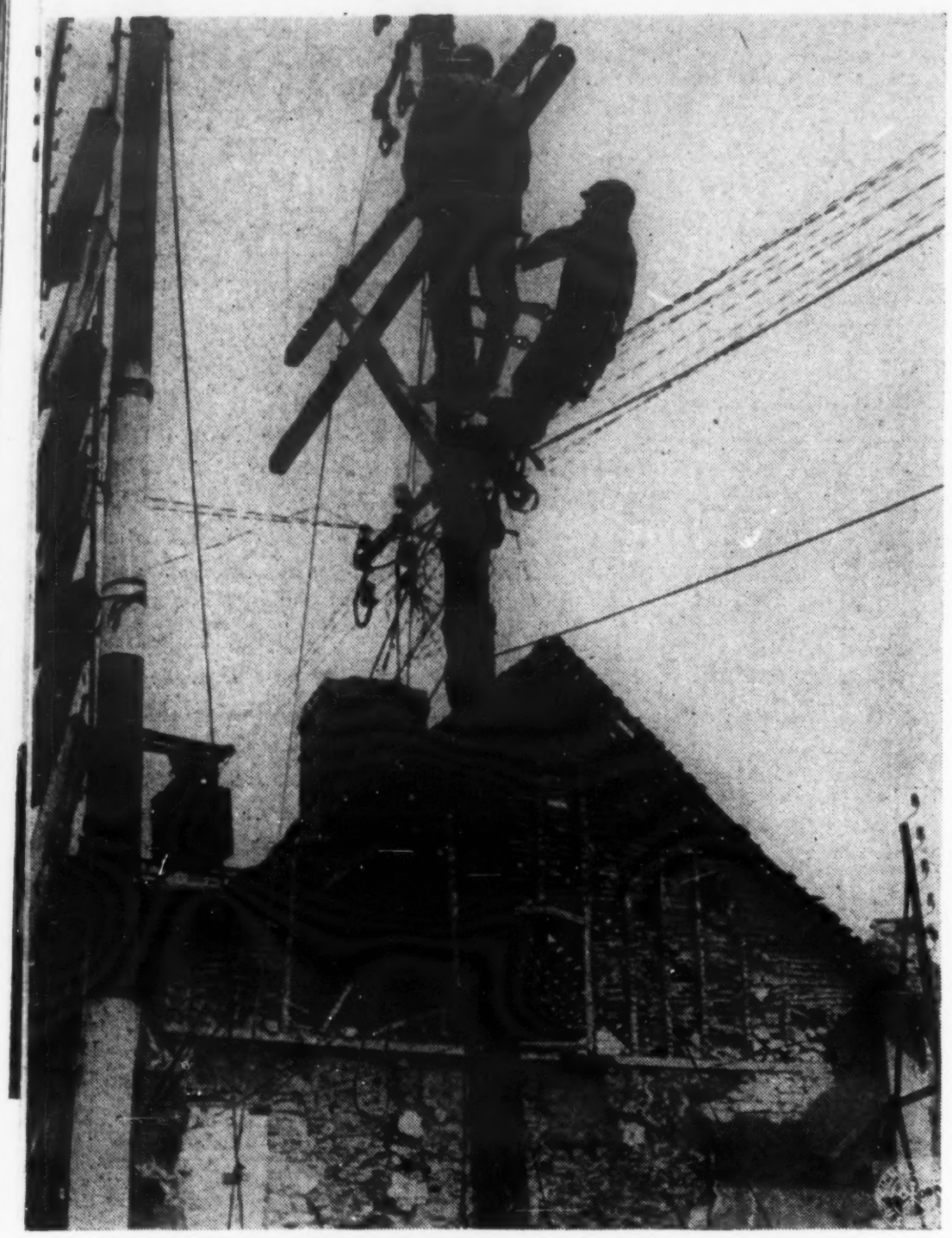
While the use of VHF radio on the Continent was planned, hindsight indicates that the value of this means for bridging gaps between operable wire areas on the Continent was not fully exploited during the planning phase. For example, had more VHF resources been available at the time of the very rapid drive from the beach-head to the Siegfried Line, it is believed less difficulty would have been experienced in the maintenance of adequate communications during this very difficult period. The time required for establishing communication between the wire system in the beach-head area and that developed in front of the Siegfried Line would have been materially shortened.

9th Army Signal men drag a cable across the Rhine.

The work accomplished on the Continent by the wire personnel, in general accordance with the plan, is an outstanding story of resourcefulness, tenacity, determination and self-sacrifice.

Radio Frequencies

It was necessary to assign radio frequencies for approximately 90,000 transmitters involved in the Operation. It is believed that this task was one of the most in-



Line repair near the Front, 1944.

tricate problems in frequency allocation ever to confront any organization, in war or peace. With the tremendous increase in the utilization of radio and electronic devices which will occur in the immediate future, this project will probably fade into insignificance but the methods adopted by the Signal staffs and the Combined Signal Board might well be used as a model for the solution of problems in allocation that will arise in the near future.

Exemplary of the problem, 3300 requests were made for channels between 1.5 and 8 megacycles by the six major services and the 27 contributing agencies, including Press and Psychological Warfare. Obviously, lengthy and difficult study and negotiations were required to provide frequencies without chaotic interference.

Messenger Service

An extensive system of messenger service by motor, train, boat and air was planned to cover the conquered area on the Continent, the Channel, and the United Kingdom. Linkage with the messenger service to Washington, D. C., and to other distant and interested national capitals was also carefully planned.

Press

Press communication is one of the most difficult problems facing an Army involved in modern, mobile warfare. Approximately 200 correspondents were assigned to each field army. Shortly after D-Day, there were over 500 correspondents on the Continent. The task of transmitting their copy with the speed which the press requires presented, among the multitude of operational demands, a very complex project. At times, the total load of press material for the United States approximated 250,000 words per day.

It was planned that mobile transmitters would move in on D-Day with the assault troops and would transmit press copy to the Press Information Center in London. From there the material would be transmitted to all of the interested home agencies over existing commercial and military facilities. When practicable, the light mobile transmitters would be replaced by high speed and powerful equipment capable of direct communication with the United States.

While military units provided the initial means, commercial radio teams were employed with each field army wherever practicable. After a few days of difficulty, the system operated reasonably satisfactorily throughout the remainder of the operation. An emergency arose at one period, when several hundred correspondents left the field armies to cover the liberation of Paris. The emergency was promptly met by placing in operation an existing French transmitter, which furnished direct service to the United States.

Dissemination of Signal Instructions

The Signal Instructions were issued in two parts: the first, containing items of general application to the entire operational force engaged; the second, pertaining to Signal requirements for Supreme Headquarters alone. Each item was issued in loose-leaf form in order that amendments might be readily entered and all copies of the instructions kept current.

Planning for Other Formations

While Supreme Headquarters and the Combined Signal Board devoted its major efforts to overall direction and planning, the army groups, armies, corps and divisions, the Naval Commands, Task Forces, and subordinate formations, and the numerous headquarters involved in the tactical air forces, air commands, groups and squadrons, were busily engaged in the detailed and immediate planning required for each and every feature of communications for the Operation.

As an example of coordinated operational, logistical and tactical planning, Operation OVERLORD may well remain as a model until field campaigns are rendered anachronistic by the application of atomic fission to modern warfare.

Coaxial Cable Systems in the U. S.

By M. E. Strieby

Staff Executive, Long Lines Dept., A. T. & T. Co.

BECAUSE OF the widespread use of coaxial cable in radar and other wartime electronic devices, the term "coaxial," in its association with the transmission of very high frequencies is widely used. It may not be generally known, however, that the coaxial structure is so old in the art that it was the subject of theoretical study by Lord Rayleigh and others nearly one hundred years ago. These students of natural philosophy found its symmetrical form capable of analysis by the mathematical tools at their disposal. Hence they found it of interest although no application was then visualized.

The first practical use of coaxial cable came about the middle of the last century when it was employed for submarine telegraphy. However, it is interesting to note that the users apparently did not realize that the armor wire, and the salt water, changed their simple grounded telegraph circuit into an effective coaxial structure which was therefore capable of transmitting higher speed signals. This fact was discovered by Bell System engineers about 1920 and was used by them shortly thereafter in the design of submarine cables capable of transmitting wider frequency bands. The submarine telephone cables installed between Florida and Cuba in 1921 utilized this technique.

Just after World War I the first so-called "carrier" systems for superimposing several telephone conversations on a given pair of wires were first introduced in this country. The schemes used involved amplitude modulation of a number of speech channels with different carrier frequencies. These sidebands were then superimposed and transmitted over the same wire line. At the distant end the various frequencies involved in these different sidebands were separated by means of electrical filters. Early open wire carrier systems provided three or four carrier telephone circuits in addition to the normal voice frequency circuit over each pair of wires.

It is interesting to note that the probable value of the coaxial line as a medium for a wide band communication system first was recognized in the early 20's by Bell System engineers. This foresight was no doubt the result of their experience gained from submarine cables, and from the first multi-channel carrier telephone systems. Operation of these carrier systems was made difficult by crosstalk between different systems on the same route. This led to the conception of a coaxial structure for wide band or multi-channel transmission in which there would be no upper limit imposed by crosstalk or interference to the frequencies which could be used. However, at that time the carrier technique was in its infancy, very high frequency amplifiers were not available, and open wires seemed to offer a better field for immediate development and use. Accordingly, no active work on long distance systems using coaxial lines was initiated.

Early Development

Under the stimulus of constantly increasing long distance telephone traffic in the late 20's, a reexamination of possible improved carrier methods was made. Better vacuum tubes and circuit techniques had then become available and seemed to offer a basis for development of higher frequency carrier systems. Accordingly, a development program was initiated in the early 30's aimed at providing carrier systems for toll cables, more conversations on each pair of open wires, and an investigation of the coaxial line as a medium for very wide band multi-channel cable systems. The higher frequency systems for ordinary toll cables and for open wire lines were completed and standard arrangements which transmit 12 speech channels on each pair of wires were placed in commercial operation in the late 30's. These carrier systems have had extensive application throughout this country and have been used to some extent abroad. They were of great value during the war in increasing circuit facilities with small amounts of raw materials.

The chief reason for including the coaxial line in this development program was that this structure has a fundamental advantage at the higher frequencies because of the inherent shielding provided by the outer conductor. This property is well understood and is illustrated in Figure 1, which shows the concentration of the energy of a 2 mc. signal in a coaxial conductor as compared to the energy distribution of a similar signal transmitted over a pair of open wires 12 inches apart. At such frequencies coaxial conductors can be operated side by side without difficulty whereas operation of more than one long open wire circuit on the same pole line would present almost insuperable difficulties. Similarly, nominally balanced pairs of wires within a cable sheath are coupled to one another by the distributed energy of transmitted signals and this coupling becomes more and more pronounced the higher the frequency. Conversely, the crosstalk coupling between coaxial

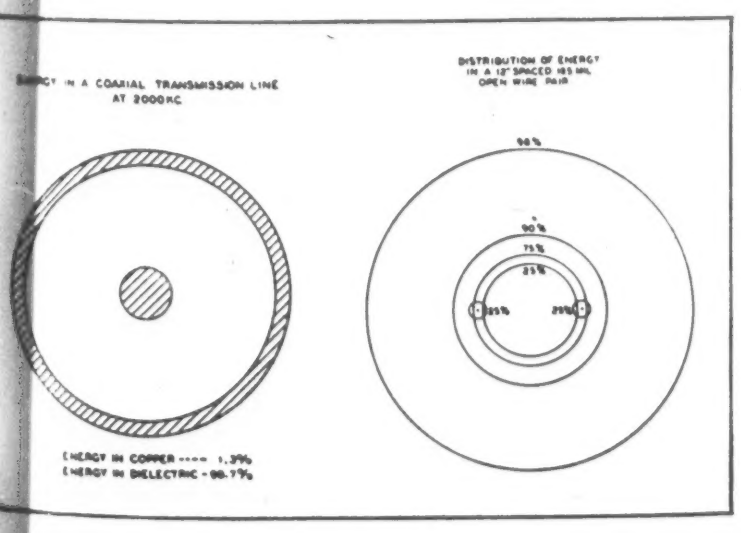


Figure 1.—Distribution of energy at 2000 kc. within a coaxial structure compared to distribution around a pair of open wires.

Coaxial: Energy in copper, 1.3%
Energy in dielectric, 98.7%

Open Wire: 25% of energy within a circle of 11 in. diameter.
90% of energy within a circle of 15 in. diameter.
98% of energy within a circle of 30 in. diameter.

structures becomes less the higher the frequency. This relationship is illustrated by Figure 2.

The development of a coaxial system, because of the objective of a very wide frequency band, encountered many new problems in providing vacuum tubes, filters and other circuit designs, as well as mechanical and electrical problems in the manufacture of the cable itself. The early development work included a field test with a copper pipe a mile long and 2½ inches in diameter. Within this, and supported by porcelain insulators, was mounted a smaller pipe, and within that pipe a wire. Thus two sizes of coaxial conductor were available for test. The objective was to check the theory of transmission and interference. This involved the development and construction of new measuring devices. An excellent agreement with calculations was obtained, and the next important phase of system design was undertaken.

First Workable System

By 1934, the elements of a system for transmitting a band a million cycles wide had been constructed in the laboratory. This system was designed to handle 240 two-way telephone conversations on a two-pipe cable. Repeaters were to be 10½ miles apart, to receive their power over the coaxial line, and to employ feedback. This system was installed and tested between New York and Philadelphia in 1936. It proved to be a feasible medium for handling large numbers of telephone channels simultaneously. This system, because of its unique wide-band transmission capability, also offered a method for transmission of television images. Accordingly, a special television system was designed in order to test out this feature of the million cycle coaxial system. A specially designed mechanical scanner for producing 240-line television images was built for the transmitting end and a specially designed cathode ray tube for the receiving end. Great precautions were taken in this design to make the television system itself a good enough laboratory tool so that defects in the coaxial transmission line could be observed. This system utilized a frequency band of about 800 kc. and tests with it showed that the coaxial system was capable of transmitting such wide band signals with a high degree of fidelity. Furthermore, these tests gave a means of determining experimentally the approximate technical requirements for such television transmission.

A most important requirement for any long distance telephone system is its reliability in providing trouble free facilities. Because of the large number of vacuum tube repeaters in the coaxial system there was, naturally, considerable doubt that such a system could be made sufficiently reliable. Accordingly, the New York-Philadelphia system was set up for regular operation so as to

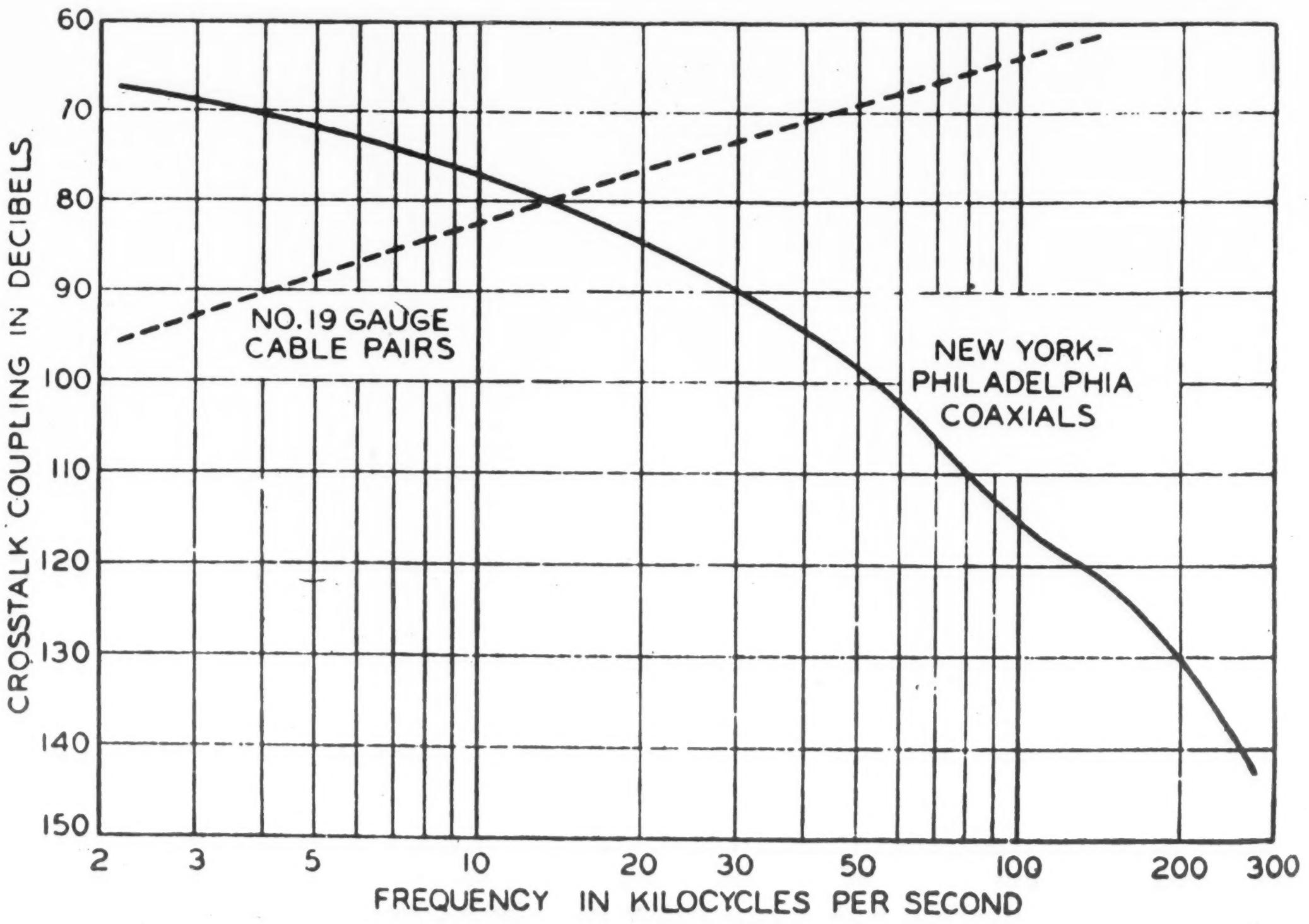


Figure 2.—Typical crosstalk values for ten miles of 19-gauge cable pair and the coaxial structure.

make continuous observations on its performance.

A Two Million Cycle Development

During this period, and encouraged by the success of the million cycle system, development effort was turned toward utilizing new vacuum tube techniques in the production of an even wider band coaxial system which would at the same time have a higher degree of reliability. The vacuum tubes available seemed to offer the possibility of a system to transmit a two million cycle band carrying 480 telephone circuits; accordingly, design of such a system was immediately undertaken. Because of the high attenuation in the coaxial cable at such frequencies, and the inherent limitation due to resistance or thermionic noise, it seemed best to put the repeaters of the new system at half the previous spacing or about 5¼ miles apart. To provide greater reliability two fundamental steps were taken in the design of this system. First, the amplifiers, which were of the three-stage feedback design, were provided with two tubes in parallel in each stage so that the failure of any one tube would not appreciably affect the operation. Second, the provision initially of a four-pipe system in which a complete spare pipe, fully equipped with repeaters, would be provided for each direction of transmission. The idea was to have transmission normally carried on both the regular and the alternate line. Then, at suitable intervals, an automatic switching device would be provided so that if the transmission on the normal path departed by more than a predetermined amount, transmission would be so switched that the alternate pipe with its repeaters alone would carry the load. As a further precaution, this switching device was so arranged that it would not switch unless the transmission on the alternate pipe was up to par.

This two million cycle system was designed for more or less standard factory production and was applied to the New York-Philadelphia cable in 1939 as a preliminary field test. As a result of these tests, certain modifications were made and fairly complete tests of load carrying capacity, stability, amplitude and delay distortion were carried out. In order to explore the operation of

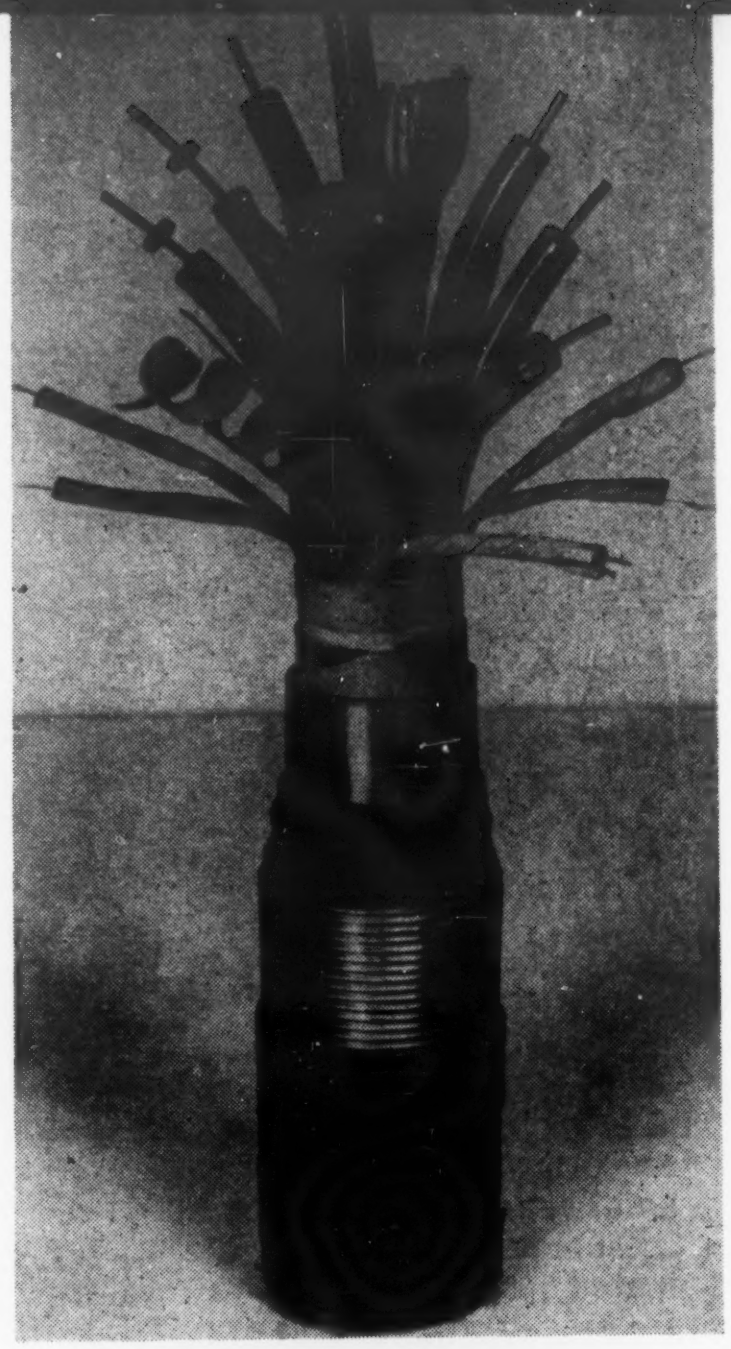
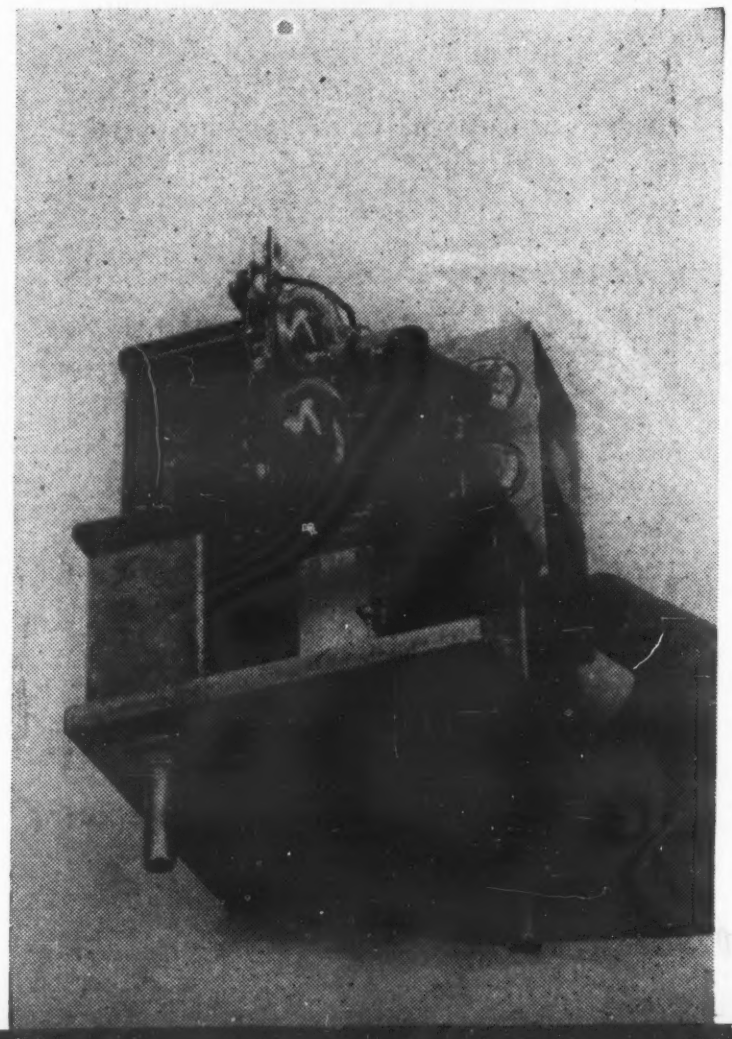


Figure 3.—Section of modern 8-tube coaxial cable of type used for new transcontinental installation now under construction. (Cable fanned out to show 8 coaxial conductors and the forty-eight 19-gauge wires used for signalling and maintenance.)

this system for television transmission, equipment for 441-line scanning, as was then standard, was constructed. While the coaxial system was designed for a

Figure 4.—A 3-mc. coaxial amplifier with cover removed.



top frequency of about two million cycles for telephone, it was found that the television requirements were somewhat less severe at the higher frequencies and that, with minor modifications, this system could be operated to a top frequency of a little over 3 mc. Tests between New York and Philadelphia in June 1940 showed that very acceptable transmission of 441-line television signals was feasible, at least for such distances.

Three Million Cycle Commercial Installation

As this system seemed to meet technical requirements, a full-scale field trial was undertaken with a view to putting the system into commercial service. A location was chosen, where additional telephone circuits were required, between Stevens Point, Wisconsin, and Minneapolis, Minnesota, a distance of 200 miles. A four-pipe coaxial cable was installed on this route, 150 miles being placed underground and 50 miles being placed aerially so that experience with the operation of an overhead system could be obtained. This installation was completed early in 1940 and was subjected to extensive tests. Numerous troubles were encountered, as can be expected with any new system. One unexpected source of trouble was an unusual amount of lightning damage. While this location was known to have heavy lightning storms, the effects were found to be more severe on this cable than on ordinary toll cables because the small amount of copper and lead in the cable did not provide as low impedance to lightning currents as did the larger multi-wire cables. On this route and on subsequent installations where necessary, additional conductivity has been provided in the cable or by burying copper wires near the cable. Operation with the full complement of telephone circuits for distances as great as four thousand miles was proved to be feasible. Furthermore, the transmission of a 3 mc. television image was tested out for a distance of 800 miles by looping the transmission back and forth. While this transmission showed some unwanted effects of delay distortion, the results seemed to indicate that successful operation could be anticipated for at least such distances.

At the time these tests were completed, and the cable put in regular commercial service in June 1941, the effects of the war were beginning to be seriously felt. This was evident in two ways: first, the diversion of development effort to wartime needs; and second, the growing demands for long distance circuits, particularly on the transcontinental route. These circumstances combined to bring about a cessation in the installation and development of coaxial systems and concentration of effort on the installation of cable carrier, open-wire carrier systems, and other means which seemed less speculative, to meet the wartime demands. The New York-Philadelphia and the Stevens Point-Minneapolis systems, however, continued in service and the experience gained with their operation gradually made possible the elimination of various troubles which became evident in commercial operation. Toward the end of the war when material shortages became serious, it became desirable to resume the manufacture of coaxial cable because of the smaller amounts of lead and copper employed in its construction. Concurrently a program was initiated for installation on a country-wide basis.

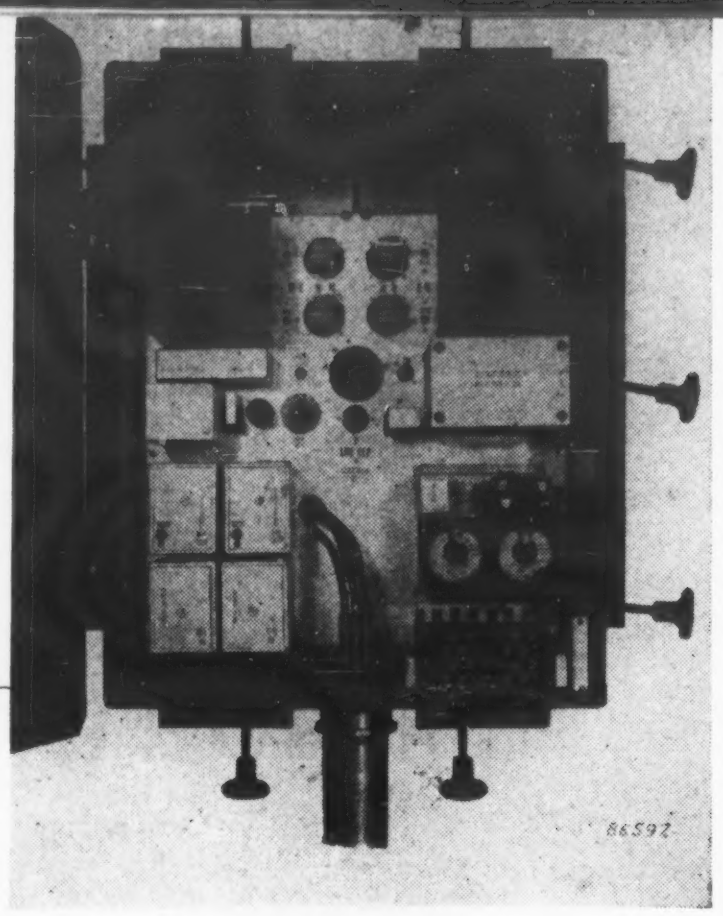


Figure 5.—Two-way repeater for 3-mc. coaxial cable system.

Present Standard System

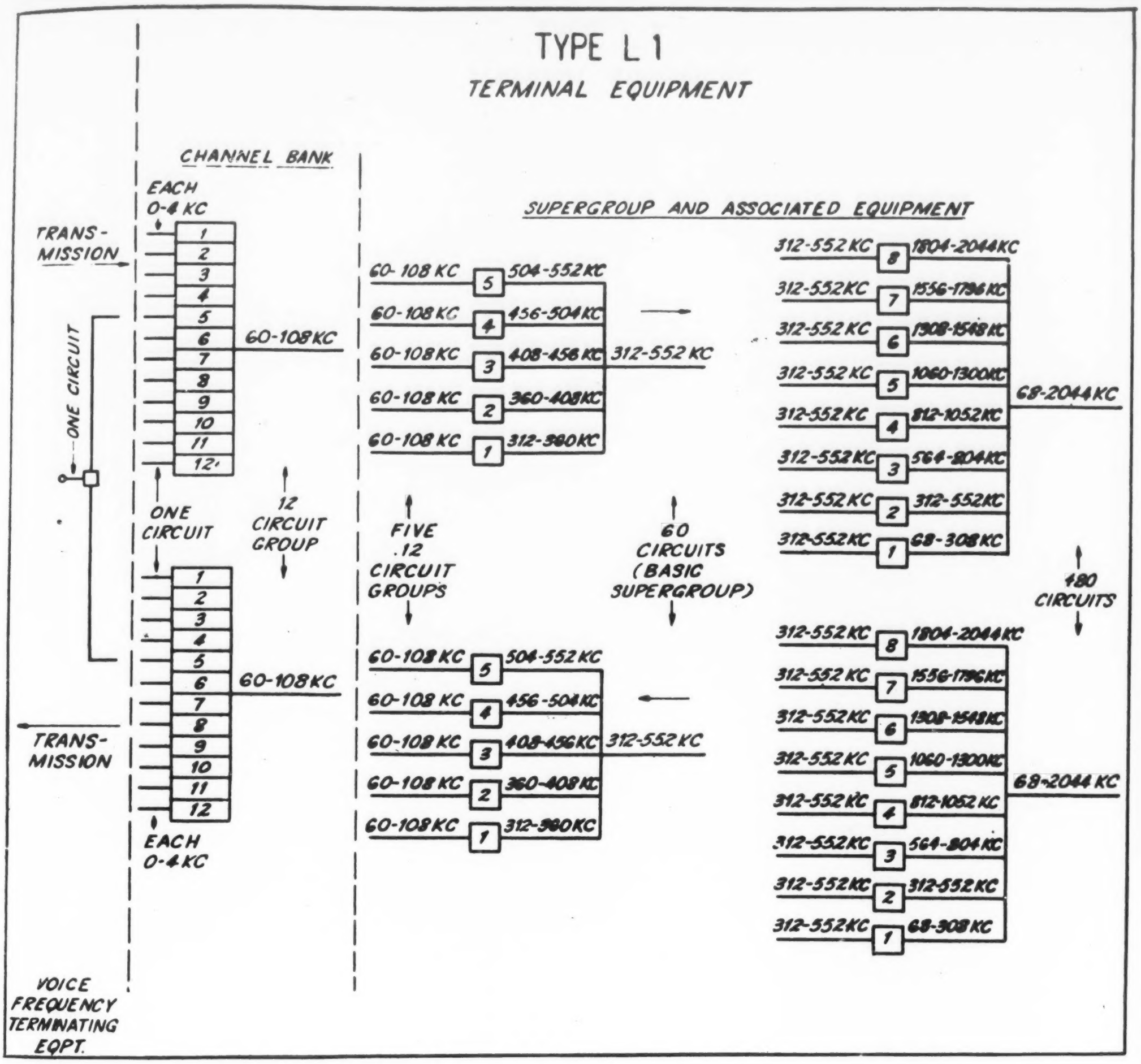
The 3 mc. coaxial system developed before the war is known as the Type L-1 system and, with minor modifications, is now being installed on a large scale. Accordingly, the components and the performance of this system are of present-day importance and will be described below.

Coaxial cables installed prior to last year contain coaxial tubes .27 inches in inside diameter with an inner conductor of solid copper .070 inches in diameter. The insulation consists of hard rubber or polyethylene discs spaced about ¾ of an inch apart, as illustrated in Figure 3. This arrangement results in an average dielectric constant only about 10% greater than air and an impedance of about 75 ohms. at the higher frequencies. The outside conductor is made of a thin longitudinal copper tape folded around the insulators and held in place by teeth on both edges which lock together. This structure is then bound down by two layers of steel tape which provide mechanical strength and some additional electrical shielding. More recently a somewhat larger coaxial conductor has been adopted as standard because of the anticipated extension in the usable frequency range of coaxial systems to much higher frequencies than were originally contemplated. This new conductor has an inside diameter of ⅜ of an inch with other dimensions proportionately increased so that it has substantially the same electrical characteristics except that its attenuation at any frequency is sufficiently lower to enable a nominal repeater spacing of about 8 miles to be used instead of the 5½ mile spacing required by the prewar cables.

Repeaters

The repeaters for the L-1 system are built around a small-size, high gain Western Electric pentode, designed especially for use in wide band amplifiers. This tube, incidentally, when mounted in a different envelope, found very wide and important usage during the war under the code number 6AK5. The coaxial amplifier uses a 3-stage circuit with feedback, the overall gain at the top frequency being about 50 db with somewhat lower gains at the lower frequencies. The design is such that the amplifier gain is just equal to the loss in a fixed equalizer plus the average loss in a repeater section of line, which is 5½ or 8 miles depending upon the size conductor in the cable.

As the line loss is due mainly to losses in the copper, its variation with temperature is substantial and even with buried cables amounts to about 10% in the course of a year. In order to take care of these changes due to temperature, automatic regulation is provided by means of a pilot frequency at 2064 kc., which is transmitted from end to end over the coaxial system. This frequency is picked off with a narrow band crystal filter at points where regulation is required, usually the output of every second repeater. The control of the amplifier gain, including the desired shaping of the gain over the frequency band, is provided by a network in the feedback path. The variable element in this network is a thermistor, the resistance of which depends upon its temperature. This thermistor is heated by the power derived from the pilot frequency in a circuit so arranged that if the repeater output is low the thermistor will act to raise it or, conversely, if the repeater output is high the thermistor will decrease the gain. This automatic control scheme, first developed for coaxial feedback repeaters, has also been applied to the later-design type K cable carrier system. The action of such a control is substantially perfect, even in a long system, at the pilot frequency. However, at other frequencies in the band, the relatively simple equalizer networks result in systematic departures from the desired uniform characteristic. In order to keep these departures within satisfactory limits on the coaxial system, three additional pilot frequencies at 60 kc., 556 kc., and 3096 kc. are used which actuate variable equalizers at the main or attended repeater stations along the line to hold the overall transmission at these frequencies within desired limits. No opportunity has yet been afforded for testing extremely long straightaway coaxial systems so that the overall performance which can be obtained is not yet known. On the basis of present performance, however, it appears that no serious difficulty will be encountered in providing satisfactory telephone circuit operation for transcontinental distances. For television operation, however, because of the much more severe requirements, particularly on delay distortion, it appears probable that more exact



equalizing methods and equipment will be required before this system can be considered satisfactory for transcontinental use.

Because of the close spacing of coaxial repeaters it is highly desirable to economize on their housing arrangements. Accordingly, two important features have been incorporated in the system design to make this possible. The first of these is an arrangement for providing power for operation of the repeaters over the coaxial line itself. This power is supplied at 60 cycles between the two inner conductors of a pair of coaxial tubes, the mid-point being grounded to the outer conductor. This power is supplied on a constant current basis, thus avoiding any variation in the voltage supplied to each repeater by changes in the copper losses in the line as the temperature changes. The maximum rms. voltage which it seems safe to use for this purpose is about 1300 volts on the small-size cables and 2000 volts on the present-design cables. Eight repeaters in each direction may be fed from a power supply point on the smaller type cables and ten repeaters in each direction on the larger cables. The other design feature which makes for simplification of the line repeater installation is the provision of automatic signaling arrangements whereby conditions at the line repeaters are made known to a maintenance man at a main central station many miles away. At the unattended repeater, the most important information is whether or not the 2064 kc. pilot frequency is being transmitted at the proper level. If this level departs from normal by more than a predetermined amount, a relay contact is closed and a d.c. signal operated on an ordinary pair of wires in the same cable appears before the maintenance man at the control station. By a simple test on this control pair, the maintenance man can determine which amplifier of the many under his control is in trouble and whether the trouble is too high output or too low. This information is usually obtained before the system gets so far out of line that transmission trouble has resulted. Hence the maintenance man has time to take steps for the removal of the possible trouble. For example, he might

elect to switch the system onto the alternate line in that section and send someone out to make special tests on the repeater which had an incipient trouble.

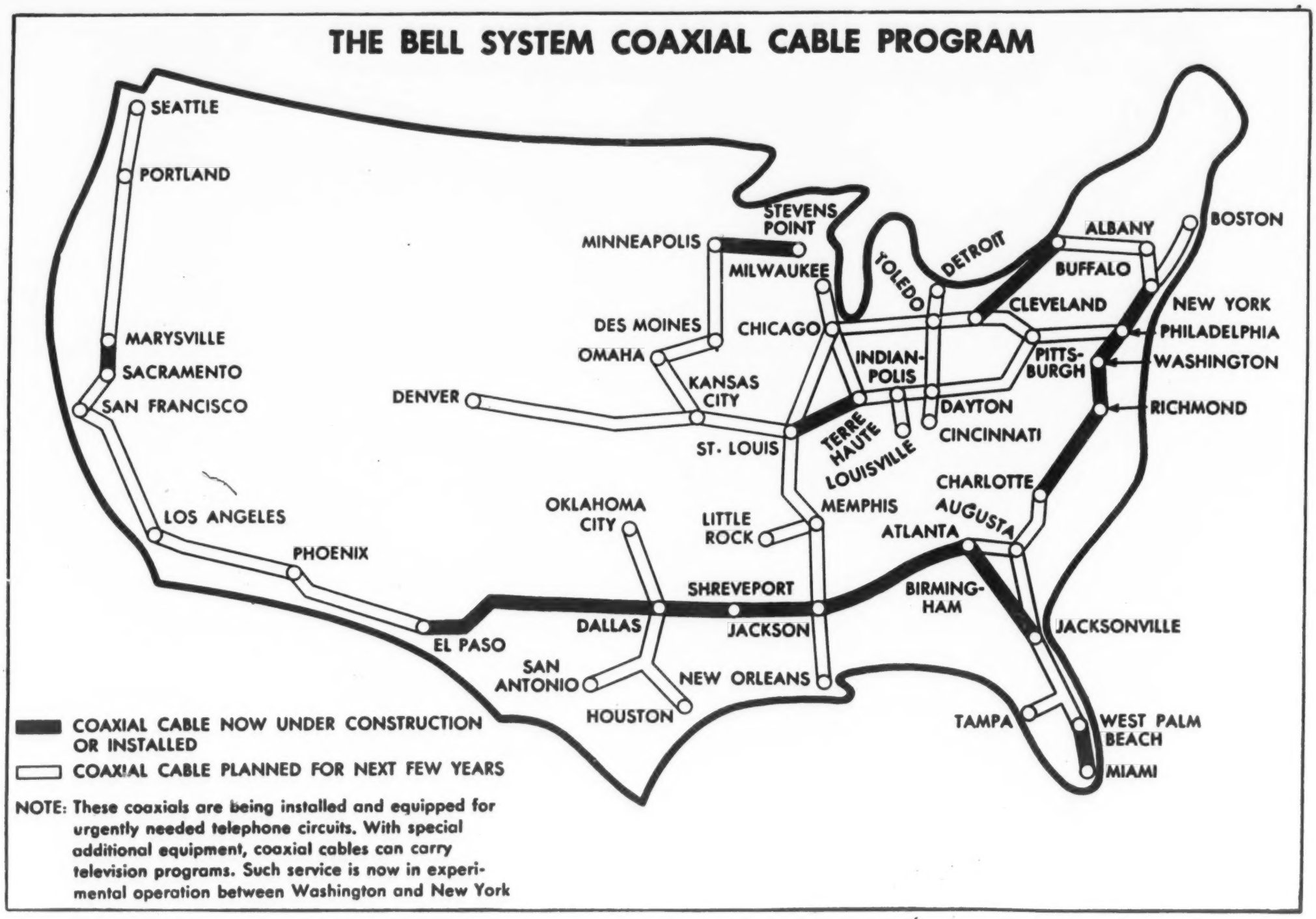
Figure 4 shows a view of the 3 mc. coaxial amplifier with cover removed. It will be observed that it is an extremely compact design arranged to plug into a socket, much as a vacuum tube is plugged in. Normally the cover is soldered into place and a small amount of drying agent enclosed within the amplifier so that no difficulty with its operation is anticipated until such time as a tube may fail. For ordinary maintenance the amplifier is removed from its socket and a new amplifier plugged in. The old amplifier is then returned to a central bureau for tube replacement and repair, as required. Figure 5 shows a complete two-way repeater which includes two amplifiers—one for each direction of transmission—together with their automatic regulators, power supply filters, automatic relays, and means for carrying out the various maintenance operations.

Terminals

To make economical use of a wide-band transmission system, such as the coaxial, it is necessary to provide terminal arrangements which will permit multiplexing a large number of different signals for simultaneous transmission over the system. As the principal objective of the coaxial was to provide telephone circuits, terminals for that purpose are of the greatest interest.

The frequency band required to transmit long distance telephone conversations with a suitable degre of fidelity has been determined to be from about 200 cycles to about 3200 cycles. Prior to the intensive development work on wide band systems referred to above, electrical filtering means available did not permit placing carrier channels of such width as close together in the frequency spectrum as was desired. To meet the standards of crosstalk which are deemed suitable, it is necessary to provide a selectivity of about 60 db over each channel band against the frequencies being transmitted in adjacent channel bands. The development of quartz crystal filter techniques, and improved coil and condenser filters at the Bell Telephone Laboratories, provided means for greatly economizing on frequency space because it permitted adjacent channels to be placed much closer together. With these techniques it was found possible to place a speech channel in each 4000 cycle block. As part of the coaxial development, quartz crystal filters were built at various frequencies from about 30 kc. up to a few hundred kilocycles. Because of the stability and permanence of the quartz crystal filter and its probable long term economy, it was decided to standardize on a group of 12 crystal channel filters suitable for use on coaxial, cable carrier, or open wire carrier systems. The arrangement finally adopted consisted of such a group of filters in the range from 60 kc. to 108 kc.

Each speech channel transmitted over such a carrier system is first divided into a four-wire circuit by means of a hybrid coil. On the transmitting side the signal is then modulated with a



carrier of 64 kc. for channel No. 1, for example, and the lower sideband from 60 kc. to 64 kc. selected by the channel No. 1 filter. Similarly, the next 11 speech channels are modulated with carriers of 68 kc., 72 kc., and so forth up to 108 kc. The lower sidebands in each case are selected by the corresponding crystal filters and the outputs of all 12 filters connected in parallel. With all channels active, this bank of modulators and filters produces signals in the range from 60 kc. to 108 kc. In the receiving branch, signals in the same frequency range, 60 kc. to 108 kc., are impressed on another bank of 12 crystal filters in parallel, each of which selects the sideband frequencies of a particular channel. Each filter output is then demodulated individually, by means of the same carrier frequency used at the transmitting end, and amplified to produce voice frequencies of suitable volume for use as a toll circuit. The two-way terminal equipment, including modulators, crystal filters, and demodulators with associated amplifiers for 12 speech channels, is usually built up as a unit and is called a "channel bank."

In the coaxial system, arrangements to accommodate large numbers of speech channels involve additional steps of modulation, which move groups of sideband frequencies into the higher frequencies as indicated in Figure 6. Five 12-channel groups are first combined by a second step of modulation into a 60-channel "super group," which occupies the frequency range from 312 kc. to 552 kc. Such double modulation, when first investigated for the coaxial system, seemed rather speculative; however it has since become common practice and when performed in suitable circuits can be accomplished without the introduction of appreciable amounts of unwanted modulation products.

The full normal complement of 480 telephone circuits is obtained on the type L-1 coaxial system by transmitting eight 60-channel super groups. These eight super groups are impressed, one above the other in the frequency range, by means of a third step of modulation as shown also in Figure 6. At the receiving end, three steps of demodulation are similarly employed, but in the reverse order. Equipment for these purposes has been standardized and involves group and supergroup modulators, demodulators, and wide band filters as required. If it is desired to terminate some of the circuits at intermediate points on a coaxial system, the desired part of a complete terminal can be installed and any number of circuits, for example one complete super group, terminated at that point. Thus, great flexibility of circuit layout is possible with this system.

For the transmission of types of signal other than telephone, special terminal arrangements are provided. The most spectacular such use is for television transmission. In this case the entire usable frequency band is usually required; in fact, the present standard 525-line television image should normally have a 4 mc. band for its complete transmission. The type L-1 coaxial system can be used to provide a maximum band of about 2.7 mc. sufficiently free from amplitude and phase distortion to be suitable for television. The scheme used involves double modulation of the video signal so as to place its zero frequency at 311 kc. for transmission over the line. An upper sideband of about 2.7 mc. can then be transmitted over the coaxial system. Along with this, a vestigial lower sideband of about 150 kc. is also transmitted. The amplitude and phase of the vestigial sideband and the lower frequencies in the useful sideband are carefully controlled so that upon demodulation at the far end the amplitude and phase of the resulting video signal are made substantially correct down to the lowest usable video frequencies.

For the transmission of high quality program material, wider bands are usually desired than for ordinary speech. Specially arranged terminals utilizing the space normally allocated to two or more speech channels have been designed to provide program channels of the desired frequency band. Conversely, for telegraph, narrower frequency bands are sufficient and for this purpose ordinary voice-frequency carrier telegraph terminal equipment is used to split up a normal speech channel into 12 or 18 separate telegraph channels. The transmission path over the coaxial system is sufficiently linear and stable and adequately free of noise to serve these purposes as well as for telephone service.

Current Installation and Plans

The type L-1 coaxial system, as above described, is now being installed upon a wide scale throughout the United States. Figure 7 shows the routes on which coaxial cables now exist or are being installed. It will be noticed that present installations include the main route along the Eastern Seaboard and most of the Southern Transcontinental route to Los Angeles. As of the end of 1946, about three thousand miles of coaxial cable were in the ground.

As indicated on the map, very considerable extensions of the coaxial installations are planned for the next few years. Most of the cables to be installed will contain eight coaxial conductors. These will include installations on the major telephone traffic routes of the country. The heaviest traffic route in the country is between New York and Washington; on that route there will be sufficient coaxial conductors available by the end of this year to provide for a number of television facilities as well as about 1000 telephone circuits.

The present construction schedule contemplates completion not only of the route to Los Angeles this year but also a route westward to Pittsburgh plus an extension along the Atlantic Seaboard to Miami. By the end of 1948, or shortly thereafter, installations will be extended to Cleveland, Buffalo, Detroit, Chicago, and St. Louis. Other routes to be developed shortly thereafter include New York-Boston, New York-Albany-Buffalo, and Pittsburgh-Dayton-Indianapolis-Terre Haute. The exact schedules for these extensions will, of course, depend upon the urgency of the need for such additional facilities.

Maurice E. Strieby was born in Colorado Springs, Colorado, in 1893. He has an A.B. from Colorado College, B.S. from Harvard, B.S. from M.I.T., and ScD (Hon) from Colorado College. Mr. Strieby was a Captain in the Signal Corps in World War I and a Consultant on Communications in the Office of the Secretary of War during the recent conflict. He has been with the Bell System since 1916, serving as Engineer, High Frequency Transmission Engineer, Long Lines Department Transmission Engineer, and currently, as Staff Executive.

STANDARDS IN ELECTRONICS

By COLONEL GORDON C. IRWIN
Commanding Officer, Signal Corps Standards Agency

DIVERSIFICATION, arch-foe of military efficiency, may lose a battle, a campaign, even an entire war. Superiority in arms and equipment are dissipated when repair and supply functions in technological warfare are complicated by lack of standardization.

Just prior to World War II there was an overwhelming confusion in the available supplies of component parts for those equipments used by the Army that were in general industrial manufacture. This chaos could easily have impeded the war effort to the extent that victory might have been delayed by many months and thousands of additional American lives would have been sacrificed to the cause of industrial individuality.

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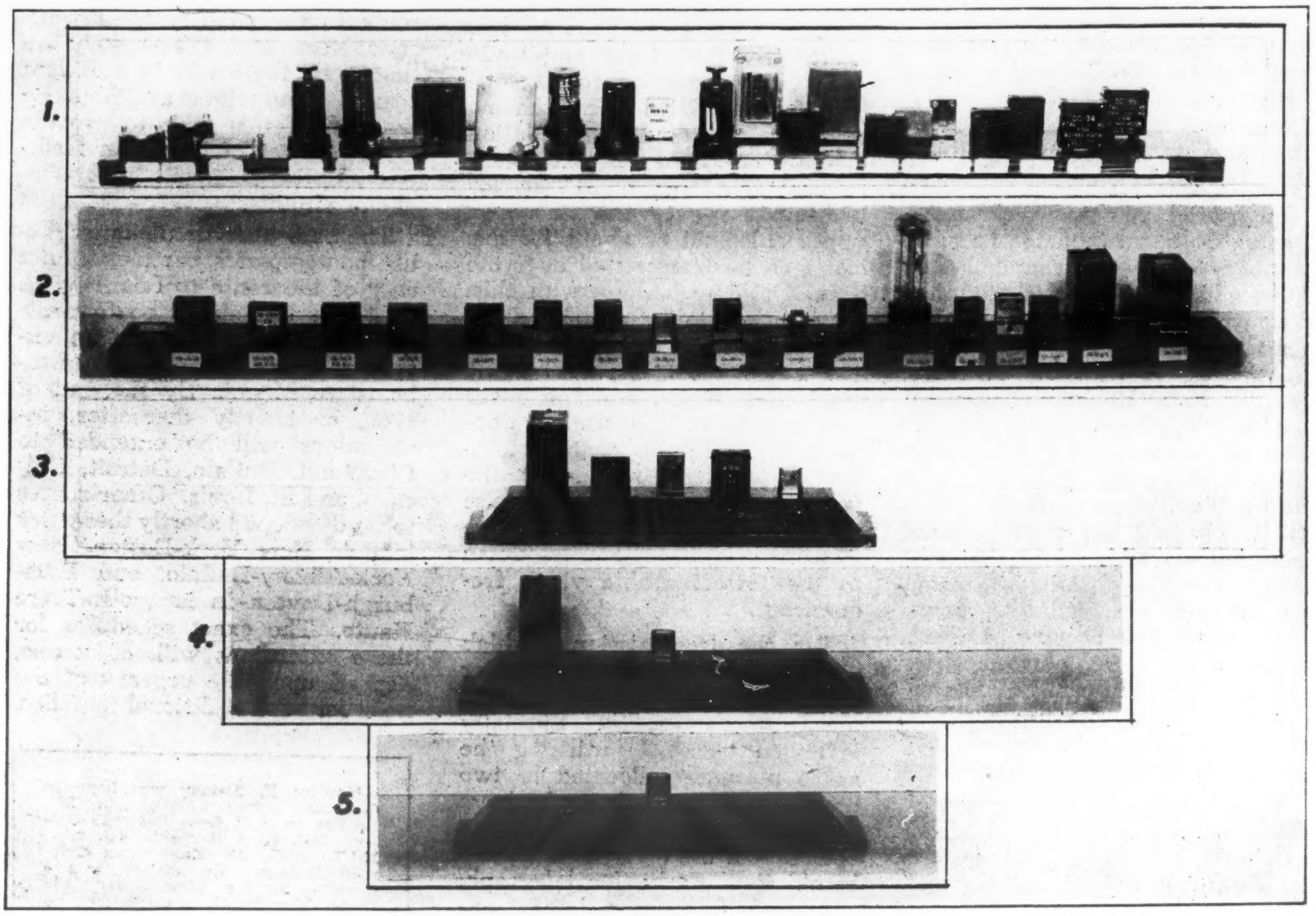
The Honorable Louis Johnson, then Under Secretary of War, delivered his famous lecture, "Battle Axes To Bottle Necks," in the Spring of 1939. Addressing an audience of procurement planning officers and students at the Army Industrial College in Washington, he emphasized the serious problems that would be encountered in the projected Industrial Mobilization Plan and discussed possible solutions. This meeting marked the first attempt to grapple with the tremendous task facing an Army mobilized for global campaigns.

Without standardization, Signal Corps logistics, in particular, was hopelessly burdened with a surfeit of sizes, shapes, types, mountings, and a serious variation in quality of material. This intolerable condition made it necessary to carry in stock, all over the world, hundreds of duplications of components, each having identical electrical characteristics, for the adequate supply and maintenance of field equipment. One or two standard items would easily have sufficed.

Rectification

The first step to achieve order in Army electronics was a contract executed by the War Production Board with the American Standards Association in June 1942, out of which came a few "American War Standards" on



The Standardization Cycle.

1. First Step. 22 holder types, with closer tolerances requiring approximately 125 electrical specifications.
2. Second Step. 7 holder types, requiring 17 electrical specifications.
3. Third Step. 5 holder types, requiring 11 electrical specifications.
4. Fourth Step. 2 holder types, requiring 6 electrical specifications.
5. Ultimate Goal: 1 or 2 holder types, not to exceed 12-15 specifications.

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To accelerate this work, the Signal Corps Standards Agency was organized at Fort Monmouth, New Jersey, on 1 January 1943. This unit assumed complete responsibility for electronic standardization on 17 December 1943. The American Standards Association had delivered twenty-one American War Standards, two of which are in current use by the Services. Most of the others form the bases of presently issued JAN (Joint Army-Navy) Specifications.

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Program

The standardization program was designed to:

a. Simplify the number of types and sizes required and to provide uniform type designations, resulting in increased production because of fewer variations, reduction of inventory in supply establishments and facilitation of replacement of parts in the field.
b. Insure interchangeability of all component parts having the same type designation, regardless of the manufacturer, purchaser, or using service.
c. Provide for grades and classes of quality, thus permitting the use of the lowest suitable grade when applicable and saving the better grades which are usually more difficult to produce.
d. Effect a saving in strategic and critical raw materials.
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The Standardization program has three distinct but inter-dependent phases:

a. The preparation, promulgation and revision of standard specifications.
b. The test and approval phase, including qualification tests under the standard specifications and the issuance of qualification approvals.
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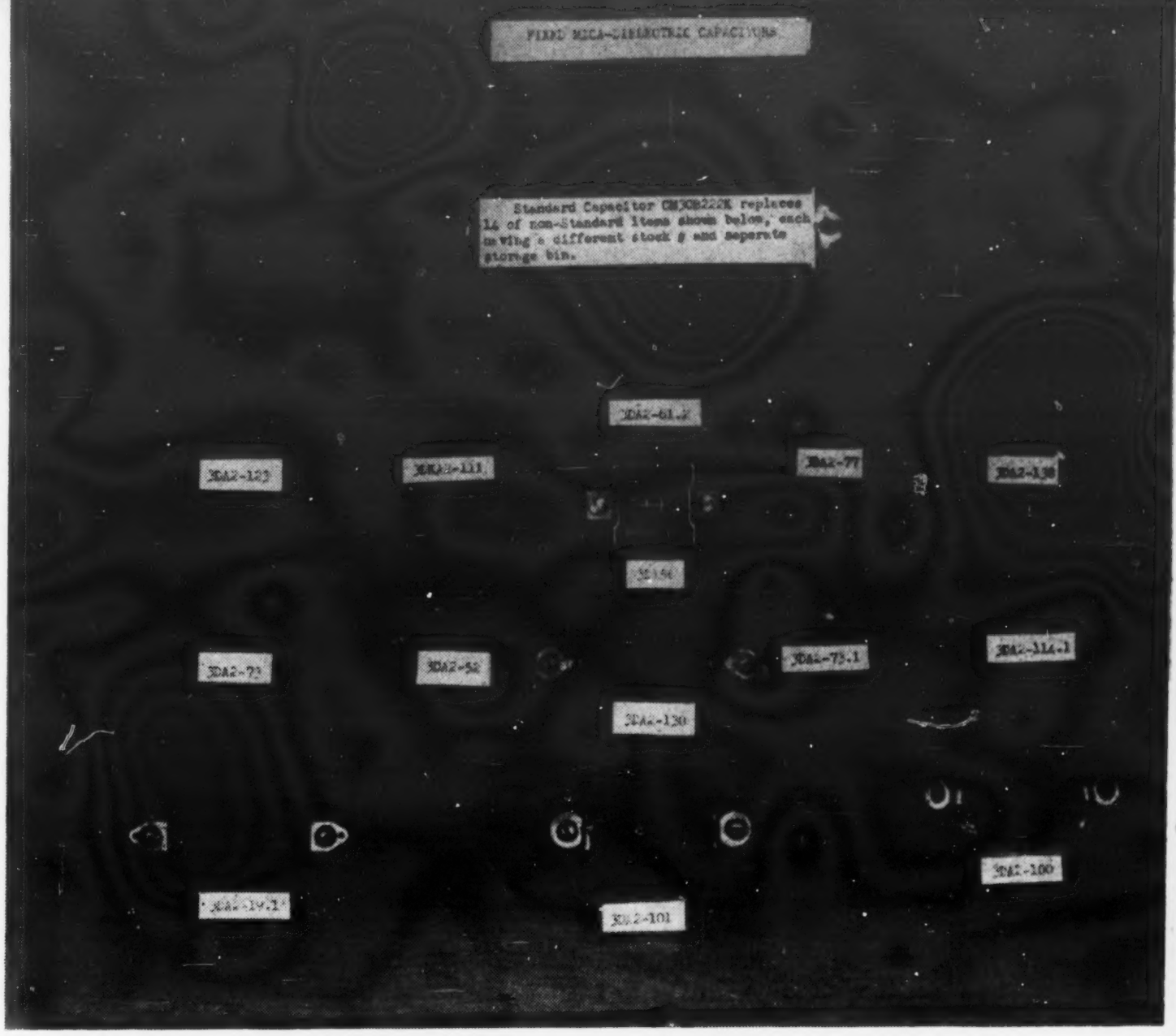
Current Operations

At the present time there are in force fifty-eight standard specifications issued by the Agency; seven are nearing completion; and it is estimated that forty-four others will be issued when the work load of the unit will permit their processing. These specifications include radio electron tubes, capacitors, measuring instruments, insulators, resistors, plastics, crystals, coaxial cables, batteries, rheostats, switches, sockets, connectors, wave-guides, transformers, dynamotors, plugs, jacks, wire, and numerous others.



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Notable contributions to the success of the standards program have been made by technical societies, standards groups of industry associations and educational institutions.

AESA now has an authorized strength of ten officers and ninety-three civilian employees. To them is entrusted the task of maintaining the high standards that have helped make the electronic and communication equipment of the United States Armed Services second to none in performance and quality.

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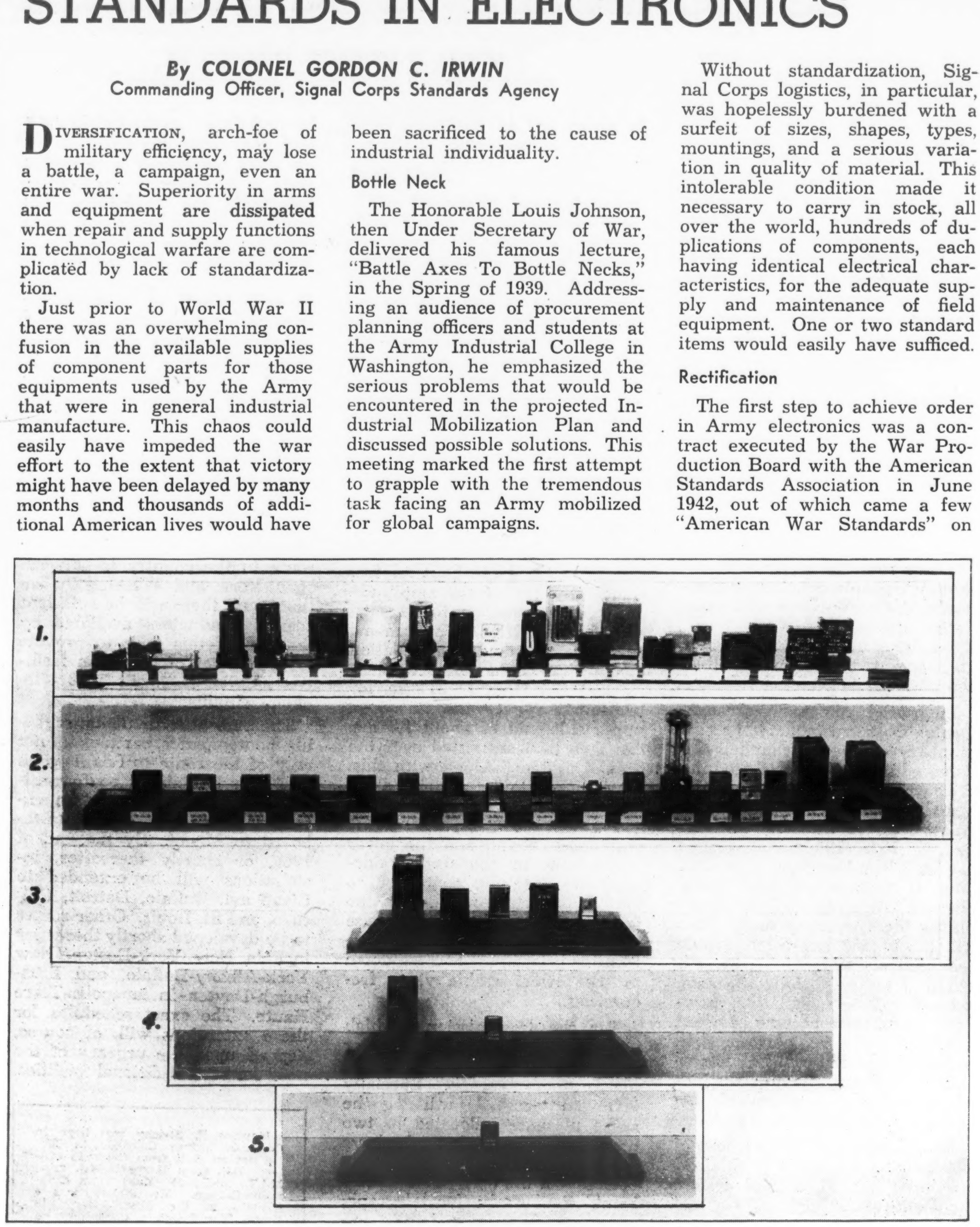

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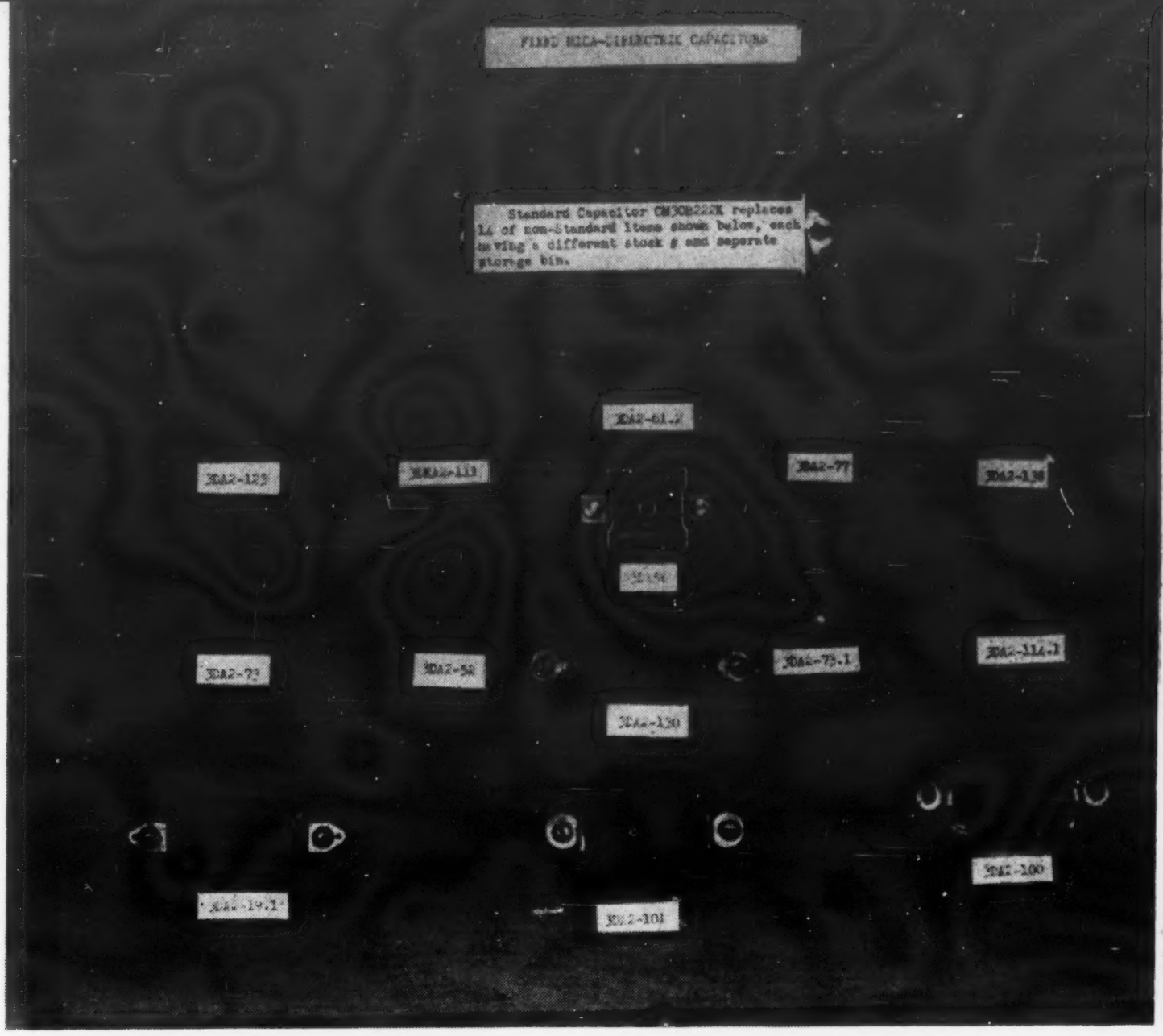

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Military Training for Industrial Planning

By Brig. Gen. E. B. McKinley

Commandant, Industrial College of the Armed Forces

DESIGNATION, on 26 April 1946, of the Army Industrial College as "The Industrial College of the Armed Forces" reflected, in the full participation of the Navy Department, the achievement of the objectives toward which the College had been evolving since its establishment in 1924.

The almost-disastrous effects of the failure of the United States, prior to World War I, to devote adequate attention to national defense, and, particularly, the lack of understanding of the enormous problems involved in the direction of our vast productive machinery into the requirements of a large-scale war, were bitter lessons for the civilian officials and officers of the War and Navy Departments.

The resultant National Defense Act (as amended 9 June 1920) laid down the broad outlines of a plan to provide for industrial mobilization in the event of another war by charging the Office of the Assistant Secretary of War with the responsibility of supervising the procurement of all military supplies required by the War Department and the mobilization of industrial organizations. The need for a program of implementation and personnel training was immediately apparent.

On 11 October 1923, the Assistant Secretary of War, the Honorable Dwight W. Davis, suggested the inauguration of "special courses" to train officers "in the useful knowledge pertaining to the supervision of procurement of all military supplies in time of war and to the assurance of adequate provision for the mobilization of materiel and industrial organizations essential to war-time needs." This "suggestion" led to the creation of a new training school, the Army Industrial College, which convened its first term on 21 February 1924.

In the Navy Department, the problems of industrial mobilization were given equal recognition and Naval officers were enrolled in the College as early as 1925, during the second year. With Navy participation, the sources of study were modified to meet the newly extended mission of the institution. The realization of the true complexity of industrial mobilization led to a steady evolution of the program of the College. By 1926 it became necessary to lengthen the course from the original five months to a full year.

Faculty lectures were supplemented by instruction by officers of the Planning Division of the Office of the Assistant Secretary of War. To improve the essential liaison between the Armed Forces and industry, and to provide for the student officers the best obtainable information on specific problems and phases of industrial mobilization, arrangements were made for addresses by outstanding representatives of the major industrial and financial organizations of the nation. Additionally, officers of the civil departments of the government lectured on the functions of the many Federal agencies in the event of a national emergency.

Thus there evolved the framework of an educational institution, created by the Armed Forces to meet the special problems incident to the mobilization of the American economy for war. It might be noted that the War Department, in creating a high-level institution for the scientific study of the industrial phases of modern conflict, was the first of the world's military establishments to enter this field.

In view of the novelty of its mission, it is not surprising that the career of the Army Industrial College was by no means free from difficulties. From its inception, it was plagued by the lack of sufficient personnel and facilities. However, the few officers associated with the College, with their knowledge of the field of industry in war, their teaching ability, their unfaltering enthusiasm for the mission, and their limitless capacity for hard work, did manage to overcome this deficiency.

Typical of the officers who fathered the idea of the College, laid the foundation of its instructional system, and directed its early operations were Colonel Charles McK. Saltzman, S.C., Lt. Colonel Irving J. Carr, S.C., Lt. Colonel George E. Kumpe, S.C., all instrumental in the growth of the institution. In the earliest days of the College these officers fostered the close relationship between it and the Signal Corps which has been maintained to the present time. The relationship of Colonel Carr to the College, first as a student in the class of 1926, then as Assistant Commandant, 1926-1929, as Director, 1929-1930, and as Executive Officer, Office of the Assistant Secretary of War, is indicative of Signal Corps participation.

a new concept in high-level instruction is achieved in the Industrial College

As the College developed, its increasing size reflected its gains in recognition by those responsible for the national defense. Although the pioneer class of 1924 had only numbered nine Army officers, the next class, including its Naval contingent, had 21 members. By 1935, the student body had risen to 52, and the Marine Corps was represented by two officers. Through the years the faculty had been slowly increased from its original two officers to eight instructors by 1935.

While the school had originally been intended for the instruction of officers of the supply branches only, this policy was broadened in 1928 and students from the combat arms were added to the class. Beginning in 1932 officers of combat arms were assigned to the College as instructors. In 1940 the scope of the work was further expanded by the establishment of a program of short courses, of four and one-half months' duration, designed to train officers to meet the urgent needs of the growing national emergency. By December 1940, the demand for trained men had grown by a geometric progression, and the College developed a new program under which four three-month courses were to be given each year. On Christmas Eve, 1941, with the country at war, the Fall-Winter Class of 1941 was graduated and, in accordance with a directive of the Under Secretary of War, the Army Industrial College suspended its functions to permit its faculty and student body to enter immediately upon the duties of war mobilization.

With the nation committed to the greatest war of its history, and with American industry charged with the most enormous supply program ever conceived—the conversion of the United States from a peacetime basis to the "Arsenal of Democracy," those responsible for the College and its evolution could take a very real pride in its 16-year record.

From the beginning, graduates of the College had been assigned to responsible positions in procurement and supply. Major Lawrence Watts, the first Signal Corps officer to graduate from the school, was, in July 1924, detailed as head of the Procurement Planning Section, Office of the Assistant Secretary of War. The respect of the higher echelons for the work of the Army Industrial College, and the abilities of its graduates, increased until, by 1927, of the 91 graduates, 44 were assigned to procurement planning duties. This group constituted 30 percent of all officers engaged in such activities. To insure a cadre of officers highly trained not only in procurement planning and industrial mobilization, but equally well prepared to cope with strategic problems on land and sea, it became policy in 1931 to detail two graduates of each class to the Army War College and one to the Naval War College. Initial success of this plan led to an intensified application and, of the 37 graduates in 1934, 9 percent were assigned to the Army War College, 3 to the Office of the Assistant Secretary of War, 11 to Chiefs of Branches and Navy Bureaus, and 7 to procurement duties.

The aggressive and progressive leadership of the commandants and directors of the College had secured the services of outstanding officers as instructors. Typical were the then Major (now General of the Army) Dwight D. Eisenhower, and Major (now Lieutenant General) John C. H. Lee, both of whom served as instructors on the staff of the College. It is, however, most significant that the directors of the College showed remarkable ability in detecting special qualities in so many outstanding officers long before similar recognition came from other sources. Certainly the Army Industrial College's example of full cooperation among all elements of the Armed Forces furthered the cooperative efforts of the Services during the recent war.

The importance of the College in the eyes of the various Technical Services and Navy Bureaus increased as its graduates grew in numbers and influence. As early as July 1936, out of 257 officers of the Signal Corps, 30 were graduates of the Army Industrial College, and of this number, many were later employed in procurement and planning activities. In recognition of the value of this training, the Chief Signal Officer sought to have his quota of students at the College raised from two to three. The statement that "the supply arms and services, whose school primarily this is, have been behind us one hundred percent," made by Colonel McCain, Director of the College, in 1934, remains as true today as it was at the time. This support was achieved in various ways. The early policy of detailing graduates for a brief period of duty in the offices of their several chiefs was most valuable in increasing higher echelon knowledge of the school, its program, and its products. Senior civil and military officers of the Armed Forces attended or addressed commencements and other ceremonial occasions.

The reports of the student groups became well known, and their favorable reception by the arms and services is indicated by a distribution of some 16,000 items by 1931. In addition to the general forms of liaison, the College used its special facilities in the study of particular problems of military importance. Thus, during the period from 1930 to 1942 the College studied various aspects of communications—the communications industries, electrical equipment, and communications control in war time. Similarly oriented studies were made in other technical fields. At the administrative level, the College was also able to render important services. Thus, it played an important part in reorganizing procurement districts. Its study of these districts in 1930-31 led the General Staff to ask the Chiefs of Supply Arms and Services for recommendations. A board was appointed on which a representative of the College sat, and this board made full use of reports prepared by the Industrial College students and staff. In addition, lectures and reports at the College were often reflected in the annual reports of the Secretary of War and the Assistant Secretary of War. The lat-

During recent years in his Army career, General McKinley, now Commandant of the Industrial College of the Armed Forces, has devoted his attention chiefly to the industrial mobilization problems. He received his master's degree in Business Administration at Harvard in 1937, graduated from the Army Industrial College the following year and from the Army War College in 1939. During World War II he handled budgets, estimates and programs for the Quartermaster General and served for 9 months as Acting Vice President in charge of Economic Activities, Allied Commission for Italy.

ter called on the College to make recommendations for legislation.

The College never failed to lay stress on the importance of maintaining the closest liaison between the Armed Forces and industry. In 1934 Mr. Bernard Baruch, in an address to the College, stated: "Your duty is to keep the war-making agency in such close touch with industry that when called upon, it will be able to bring to the defense of the Nation all of its resources." This sound advice was translated in the daily work of the College, and the results may be seen in the record. By the outbreak of World War II, the Industrial College had graduated 1170 officers, Regular and Reserve, of the Army, Navy and Marine Corps. The total number of officers employed in war-time procurement was 25,000. However, graduates of the College staffed key positions in the Army Service Forces, Air Forces and supply agencies of the Navy, where they demonstrated the effectiveness of their training. They had learned that war is not battle alone, but is a far-reaching social and economic trial of strength; the immediate concern of the entire nation. They had grasped the relationship between strategy and economic resources. Joint training helped minimize departmentalization in procurement and helped to broaden the thinking of key officers in all services in the overall problems of procurement for the national war effort.

In the 12 years, 1924-1936, some 50 graduates had served in the Planning Branch, Office of the Assistant Secretary of War. In 1941 the Secretary of War reported that the planning done there had been sound and flexible. Although the Industrial Mobilization Plan was not adopted, the work of the planning agencies proved to be of great value in familiarizing the Services with the problems of industrial mobilization, in providing an important nucleus of trained officers for war time procurement duties, and, generally, in facilitating the difficult transition from peace to war. The research materials and studies of the College proved of substantial use to war agencies, and its Economic Warfare Information Section was transferred to the Office of the Administrator of Export Control, of which its former chief, Lt. Colonel (later Major General) Russell B. Maxwell, became Administrator. Lt. Colonel Samuel F. Clabaugh, of the College, wrote the "Bible" of the Office of the Administrator of Export Control. In 1931 the Assistant Secretary of War had prophesied that in the event of a national emergency, the graduates of the Army Industrial College would "make a record in the procurement field comparable to that established by the graduates at Leavenworth in the conduct of military operations in 1917-18." The extent to which this prediction came true is suggested by the testimony of General Echols, a graduate, who presided over the board appointed to reactivate the College. He stated, "If it hadn't been for the Army Industrial College . . . we would not have had the nucleus and background for our whole tremendous effort for expansion."

Just two years after the suspension of the College, it was reopened by the Under Secretary of War to teach courses in contract termination, property disposal, and related subjects. To fulfill a longfelt need, a Department of Research was established on 7 March 1944, and just one year later, as there was no longer a Planning Branch in the Office of the Under Secretary of War, these activities were, for the time being, assigned to the College. In October 1945 an interim course was established to analyze and evaluate our war experience in economic mobilization and demobilization, production and procurement and handling of foreign resources.

When the Echols Board met to consider the reactivation of the College, Colonel F. H. Miles, who became the first postwar Commandant, suggested that the Industrial College and a National (War) College work together. A similar recommendation was made by the Joint Board on Postwar Army and Navy Training (the Hancock Board). In response to these recommendations, by agreement between the Secretary of War and the Secretary of the Navy, 11 April 1946, the Army Industrial College became the Industrial College of the Armed Forces, and, in August 1946, was moved to facilities located on the War College Grounds, in close physical proximity to the new National War College. The physical association of the two institutions has made possible the close and cooperative integration of their lecture programs, library facilities, services of research experts, consultative facilities. Even the messes and social and recreational facilities have been merged. Thus, military education has taken on a new breadth and stature. There can be no doubt that the once wide gap in viewpoint and perspective between the top service schools is being rapidly closed.

Today, after more than twenty years of constructive work and evolution, The Industrial College of The Armed Forces stands as a well-equipped and well oriented graduate-level institution, dedicated to the training of officers of all services for duties involving procurement planning, operation, and economic mobilization, and to the carrying on of the research essential to the full understanding and effective conduct of operations in these fields. Its tradition of academic freedom, established at the time of its inception, has been, and is being, firmly preserved. The College recognizes the fact that modern war, modern industry, and, above all, modern science and technology, are essentially and terribly dynamic. No support is offered to comfortable concepts of the status quo as a basis for operations. The staff, military and civilian, is dedicated to the maintenance of our national economic mobilization and procurement planning, training, and thinking in a condition fully responsive to the fast-flowing tides of science and industry. The biological maxim "evolve or die" has no more appropriate application than to the defense planning and training institutions of a nation in the present era. The bland assumption that our potential allies will be able, in the future as in the past, to hold off our enemies until the vast human and industrial strength of America can be mobilized has no place in a world of political uncertainty and of fantastic weapons for destruction.

Only a military establishment fully cognizant of its responsibilities, assets and liabilities can begin to assume the task of acting as shield and sword for a peaceful nation. The Industrial College of The Armed Forces is devoting its energies to carrying out its share of this mission.

SIGNAL CORPS NEWS
FROM THE CHIEF SIGNAL OFFICER

IN HIS holiday message to the Signal Corps Major General H. C. Ingles, Chief Signal Officer, said:

"This is the fourth time that—as Chief Signal Officer—I have had the privilege of extending the Season's good wishes to the men and women of the Signal Corps.

"To have been associated with the loyal Americans, military and civilian, who comprise the Signal Corps, has been an unusual honor and has given me the highest satisfaction. Your support and understanding—both in the dark days of war, and during its uncertain aftermath—were strong and unfailing and I am deeply grateful to every one of you.

"It is my sincere hope that this holiday season will find you free from anxieties—no matter where you are stationed—and that your Christmas will be truly merry and your New Year continuously happy."

* * *

The Chief Signal Officer has announced the following recent changes in field installations: The General Electric Unit, Signal Corps Procurement District, has been closed and its remaining personnel and files have been transferred to the Signal Procurement District.

The Oakland Signal Subdepot has been redesignated as the Sacramento Depot Storage Annex.

The training center at Fort Dix, New Jersey, formerly under the jurisdiction of the Chief Signal Officer, has been placed under the command of the Commanding General, Army Ground Forces.

* * *

Faced with the need for thousands of wind direction and velocity measuring devices to meet the weather forecasting demands of total war, the Signal Corps Engineering Laboratories, Bradley Beach, New Jersey, developed simplified, portable wind equipment more accurate than any previously used.

Hitherto undisclosed information concerning this equipment was released by the Office of the Chief Signal Officer.

Whereas data from pre-war wind equipment usually had to be read and recorded on the spot and later computed and interpreted, the Signal Corps model AN/GMQ-1 not only provides a wind panel which can be "remoted" in a shelter some distance away, but its dials automatically convert the data into readily usable "miles-per-hour" and compass direction readings.

The equipment consists essentially of an anemometer, or pinwheel device, and a wind vane, or weathercock, mounted on a mast and connected by wires to a panel having dials indicating wind speed and direction.

First used by the AAF Weather Service in the invasion of Italy, the AN/GMQ-1 was later employed extensively in combat zones all over the world. It was used primarily at weather stations and airfield control towers, with the Artillery using it for obtaining data for firing corrections and sound ranging and the Chemical Corps using it in connection with screening tactics.

* * *

Major General H. C. Ingles, Chief Signal Officer, was the principal speaker at the recent opening of the basic course for officers at the Fort Monmouth Signal Corps Schools.

Thirty-eight students were in attendance, including twenty-six 1946 graduates of the United States Military Academy, five Chinese, five Mexican, and two officers from the Philippines.

In extending a special welcome to the foreign officers, General Ingles said, in part: "I am glad to have an opportunity to talk to the class and on behalf of the whole Signal Corps I want to particularly welcome those officers from other countries. We are very glad to have you and I hope that you can take back to your country a good deal of knowledge which will be of assistance to your armies.

"You know there is probably no part of the military profession that is as much a part of all other components of the military profession as communications. Communication in itself has no particular virtue but its great importance is that it furnishes a commander with his channels of command."

* * *

Two General Electric Company executives—Dr. W. R. G. Baker, Vice President, and William B. Cliff, Assistant Controller—were recently presented with War Department Certificates of Appreciation by Brigadier General Calvert H. Arnold, Chief, Procurement and Distribution Service, Office of the Chief Signal Officer. The ceremony took place in the offices of the company at Schenectady.

The citation accompanying the award to Dr. Baker read as follows: "For outstanding contributions to the war effort by the development and design and production of complex Signal Corps radio and radar equipment."

Mr. Cliff's citation was as follows: "For his contribution to the Signal Corps program for the settlement of all General Electric Company contracts under the Company Wide Settlement Program."

* * *

Representatives of the Office of the Chief Signal Officer arranged an exhibit of meteorological equipment at the recent International Science Exhibition sponsored by the American Association for the Advancement of Science.

Equipment developed by the Signal Corps was displayed in relation to the weather charts prepared by the Air Weather Service of the Army Air Forces in order to relate the equipment to its operational uses within the Army.

Among the equipment included was a static direction finder which can be used in networks to locate thunderstorms at distances of 2,000 miles away. One of the newer uses to which radar equipment is put was demonstrated in the radar equipment which can be used to locate the precipitation areas of storms. It is particularly helpful in connection with short-range forecasting in its ability to locate storm areas on a radar scope, whose presentation closely resembles a physical map of the area.

Radiosondes which may be sent aloft on a balloon have become a common method of measuring the pressure, temperature, and humidity at higher levels. A new development is a radiosonde intended to be dropped from an airplane in flight, whose signal can be heard in the plane itself. The equipment, while useable, is still a development item requiring minor refinement.

* * *

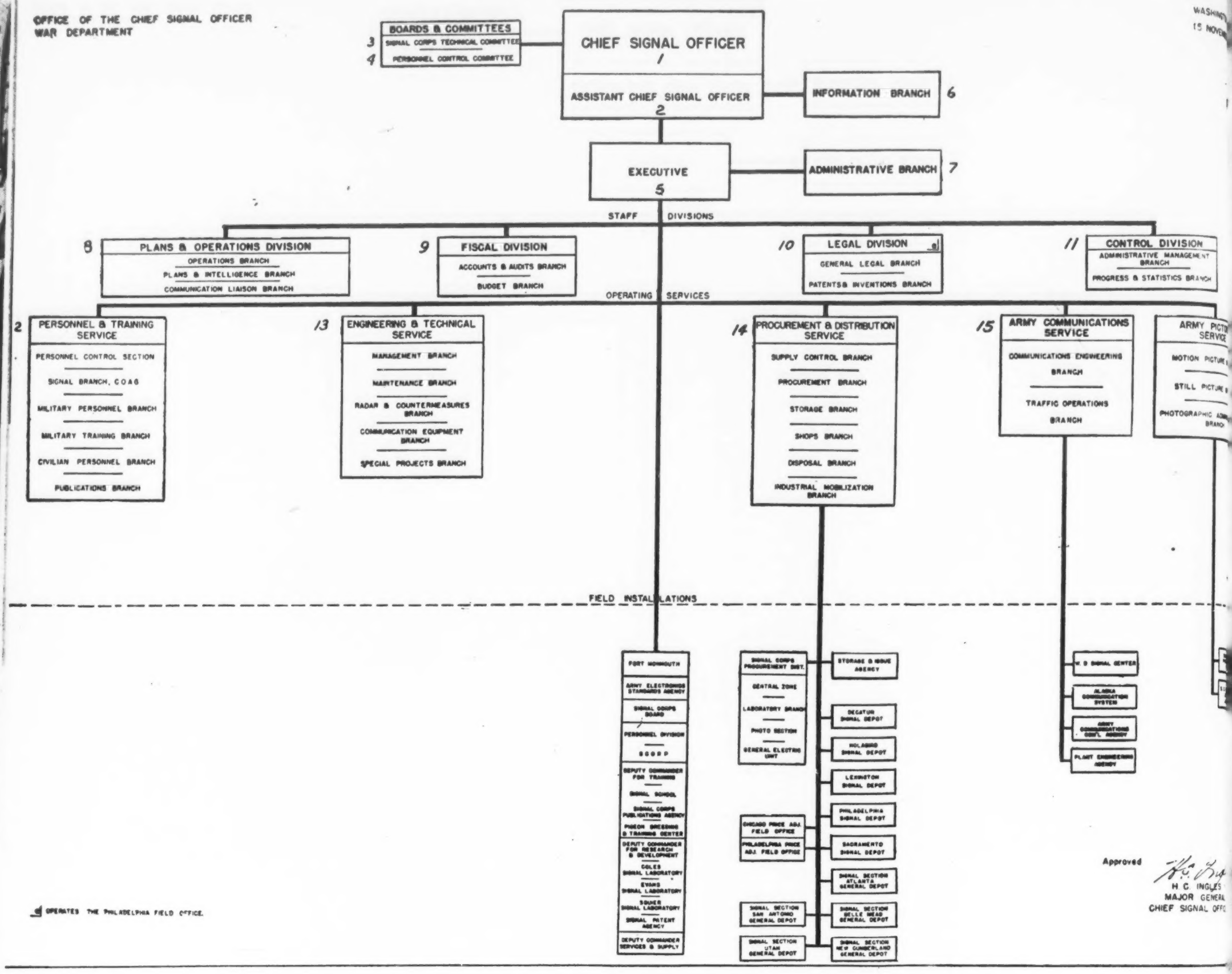
Major General H. C. Ingles, Chief Signal Officer of the Army, and Colonel Frank C. Meade, Chief, Personnel and Training Service, Office of the Signal Officer, recently addressed the First Class at the United States Military Academy on the role of the Signal Corps in the new Army based on continuing studies of future military situations and on lessons in World War II. One of General Ingles' two lectures was devoted to the techniques in modern teletyprinter conferences.

* * *

The Battery Branch of the Signal Corps Engineering Laboratories, working in conjunction with industry, has developed a line of Dry Cell Batteries that operate at temperatures of 40° below 0. No such batteries were made in the United States prior to this coordinated effort and, as a result of this effort, the United States Army was supplied with batteries of this type for cold weather operations during World War II. These batteries in outward appearance were the same in weight and dimensions as the normal temperature batteries for which they were substituted.

The success of these batteries was partially due to the substitution of Lithium Chloride in place of Ammonium Chloride. These were the only types of cold temperature batteries that were proven practical and approved for military operations.

"It has been apparent to the American people, consequently, that, with the international situation as it is, we must maintain our own armed forces at an adequate level for our own national security. True, we demobilized too rapidly, and impaired the efficiency of our fighting units. But, by reorganizing those units in the light of our combat experience, and by intensive training and re-training, Army Ground Forces has recouped much of that loss in efficiency. I am sure that our Air Forces and our Navy have similarly recovered."—General Jacob L. Devers.



1. Maj. Gen. H. C. Ingles
2. Brig. Gen. W. O. Reeder (Actg.)
3. Col. James S. Willis, Chairman
4. Col. F. C. Meade, Chairman
5. Lt. Col. James W. Baldwin
6. Capt. B. W. Quisenberry, Jr.
7. Lt. Col. James W. Baldwin
8. Col. O. K. Sadtler
9. Col. K. B. Lawton
10. Mr. John E. Pernice
11. Mr. Chas. V. Hulick, (Actg.)
12. Col. F. C. Meade
13. Col. James S. Willis
14. Brig. Gen. C. H. Arnold
15. Brig. Gen. Geo. I. Back
16. Col. W. W. Jervey

The above chart illustrates the organization of the Office of the Chief Signal Officer as of 1 January 1947. Major changes made by General Ingles when he became Chief Signal Officer in July 1943 included the establishment of separate branches for Engineering and Technical Service and for Procurement and Distribution Service. These two groups formerly functioned under a single chief.

SIGNALS IN AAF

Air University

The first class of the Air Communication Officers Course of the AAF Special Staff School, Air University, graduated on 24 January, 1947. Twenty-nine students graduated, of whom twenty are rated pilots. The last four weeks of the course was highlighted by a series of outdoor exercises employing all of the latest Air Force communications equipment including radar and navigational aids. The next course will begin on 3 February, 1947. Approximately fifty students are expected.

The Communication Division of the AAF Special Staff School has in operation a complete radar system including the latest types of ground and airborne radars and radar training devices. Although primarily intended for use by the Air Communication Officers Course, the system has proved of inestimable value for demonstration purposes to other schools of the Air University. The system includes three (3) C-47 type aircraft completely equipped with the latest type of radar equipment.

All communications systems and facilities within the Air Proving Ground Command are under the jurisdiction of the A-3, Communication Division, Hq. APGC. In view of a contemplated changeover from a commercially owned Base telephone system to an Army owned system, extensive on-the-job training programs are being conducted for telephone installation and maintenance personnel. Military personnel have been assigned to work with the civilian employees from Southern Bell Telephone Company. Much valuable experience is being gained in the operation and maintenance of an automatic dial system. WAC's were trained as telephone operators and are now used exclusively in the telephone exchange. Numerous personnel are receiving on-the-job training in the installation and maintenance of public address equipment, interphone equipment, dictaphone equipment and interoffice telephones.

Brigadier General Tom C. Rives, Chief of the Electronics Sub-Division, Air Materiel Command, Wright Field, Ohio, delivered a lecture to the students of the Air Command and Staff School, Air University, on 17 December 1946. General Rives subject was "Organization of Signal Services in the Army Air Forces." General Rives' visit was in line with Air University policy to invite outstanding guest lecture experts in a particular field to address the students of the various schools, particularly the Air War College and Air Command and Staff School.

Unusual Air Weapons

Alerted enemy anti-aircraft gunners were puzzled upon occasions during the war when our bombers, apparently coming in for a raid, would suddenly turn and leave. Their puzzle was all too short lived for swarms of winged bombs would soon start falling into their midst. AAF had a series of glide bombs, a simple method of attaching wings and controllable tail surfaces to standard 2,000-pound general purpose bomb. The glide bombs have ranges up to 30 miles from point of release. Some are designed to be guided by television cameras, radio, radar and a flight control box containing batteries, gyros and servo motors. Others use flare seeking units or heat seeking devices which seek out factories in cities that attract to the course of greatest heat, usually an industrial plant. Ten times greater accuracy against pinpoint or long, narrow targets, was provided by the now-familiar Azon radio-controlled bomb. The Azon tail assembly was fitted to standard bombs and consisted of a radio receiver, gyro, servo motor, battery, movable fins, and a flare for visual observation. The Azon is controlled by rudders attached to the vertical fins of the tail assembly, and actuated by radio link through solenoids. The horizontal fins have ailerons attached, which are controlled by gyro-solenoid combination, to stabilize the bomb in flight. Flares of various colors up to 1,000,000 candle power are provided for visual tracking during the drop. Another type of controlled air weapon used was the "Abusive," formerly known as "Weary Willies," a standard B-17 radio-controlled drone, which was loaded with explosives and dived into selected targets. Mother planes flew a formation of the radio-controlled bombers into enemy territory, where they were guided into the target area.

Artificial Weather Research

An AAF North American B-25 Mitchell medium bomber has been dispatched to assist General Electric scientists in their current study of the artificial control of weather. These scientists are experimenting with the artificial control of weather by dropping dry ice pellets into super-cooled clouds from a high flying airplane, forcing precipitation in the form of snow. If the air is sufficiently warm beneath the cloud formation, the snow immediately melts and turns to rain. The AAF will include the results of this study in its over-all program of upper air and weather research. Additional experiments are being conducted with other scientific organizations and universities engaged in basic research of atmospheric physics, including cosmic ray studies using Boeing B-29 Superfortresses.

AAF engineers have developed two explosive 'cushions' for lessening the force of impact for paratroopers. One version uses a U-shape tube, the explosive in the bend and each leg containing a charge of sand that is expelled on detonation. When discharged just above the ground, the recoil exerts a dampening effect upon the parachute load and deposits the descendee upon the ground with far less violence. Another method involves an explosive between the load and the parasol. An upsurge of air and gas is forced into the parasol on detonation, greatly attenuating the rate of fall.

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SIGNALS IN AGF

Presidio of San Francisco, Calif., December—There was speculation at Sixth Army Headquarters whether the Signal Corps boys who strung the miles and miles of wire in the recent "war" conducted by the Second Infantry Division against an assumed foe, had managed to finally spool it all up.

The quantity of wire and other signal communications means that a division in the attack needs is prodigious. Even within the relatively narrow confines of the maneuver area on the Camp Pendleton military reservation near Oceanside, Calif., where the Second Division and reinforcing units held their amphibious training exercises, a lot of wire was needed. It must have run into the hundreds of miles.

On hand to see the performance of the Second Division was General Jacob L. Devers, Commanding General, Army Ground Forces, and members of his staff. General Devers splashed ashore on D-Day off an LCVP, and got his feet wet, like any GI. Major General Paul W. Kendall, commanding the Second Division, accompanied by his Signal Officer, Lt. Col. William E. Jennings, also came ashore in one of the early assault waves and established an advanced CP. General Devers spent much time in the forward area during the operations, accompanied by Major General George P. Hays, Sixth Army Commander.

The manner in which the signal communications followed the advancing units was a miracle. Forward units, plunging deep into territory held by "Aggressor," the assumed foe who theoretically had invaded the Southwestern United States, had lines connecting with battalion CP's almost before they had set up their normal security measures.

Colonel E. R. Petzing, Sixth Army Signal Officer, described communications in the amphibious training exercises as "exceptionally well integrated." He added that in such a complicated operation, "all types of communication are a key requirement, and I am pleased to say that throughout the exercises ours went off extremely well."

More than 650 Signal Corps personnel took part in the combined operation. In addition to radio and telephone men, special still-photo and motion picture cameramen were on hand to record the events for future study, and also to provide photographs for possible press purposes.

This photography was done by the 3244th Signal Photo Platoon, which had completed its training a short time before being assigned to this exercise, at the Signal Corps Photo Center, Long Island City, New York. The unit was composed of 14 enlisted men and one officer, 1st Lt. J. M. Zinni, who had previous photographic experience in the European theater.

Before the end of the maneuver, however, the ranks of this platoon were decimated by assignments to the Byrd Antarctic Expedition. Four of the youthful photogs were roused from their bunks one night and told to prepare for a long voyage. They assembled their gear and next day were flown to the east coast to board one of the expedition vessels heading for Little America and other points far, far to the south. Their mission is to make photographs for the Army in this Navy-sponsored expedition.

Among the Signal Corps units which assaulted the beach at Aliso Canyon with the Second Division were the Second Signal Company, elements of the 286th Joint Assault Signal Company, and the 287th Signal Company with the Second Engineer Special Brigade. This brigade supplied the major reinforcing units for the Second Division's "attack."

A radio intercept company operating with the umpires found its hands—more correctly, its ears—full. Obviously, the troops on both the friendly and "enemy" sides had forgotten some of the bitter lessons of the war, for radio security, in the words of the chief umpire, Brig. Gen. Robert M. Bathurst, "was almost entirely lacking throughout the maneuver, and location of command posts, front lines, name and rank of officers were repeatedly broadcast in the clear." It is only fair to state that both the Army and the Navy had agreed to use clear radio during the actual landing.

Most worthy of mention also is the First Provisional Signal Detachment, operating a sonic device broadcasting special war-type propaganda to the opposing troops. This was modeled after psychological broadcasts during the past war. Second Division troops were highly amused by words like these blaring forth into the night:

"Soldiers of the Second Infantry, you are fighting a hopeless cause. You are being misled by your leaders. While you are here at Camp Pendleton, the Air Corps boys from Tacoma (Wash.) are going out with your wives or sweethearts. We have come into your country to get rid of the corrupt political leaders who are oppressing the people. Soldiers, it is not dishonorable to surrender when the odds facing you are so great."

Lt. R. F. Mitchell and the personnel of this Provisional Signal Detachment so impressed officers of the Sixth Army, War Department and AGF observers with their operations that it has been decided to make this organization a part of the Training Reserve and permanently assigned to the Ground General School at Fort Riley, Kansas.

The first successful study of the lower ionized layers of the upper air regions was completed in late November at White Sands, New Mexico, when an Army Ordnance V-2 guided missile containing special instruments, installed in its warhead by Air Materiel Command of the Army Air Forces, rose to an altitude of 63.5 miles.

The missile was fired an hour earlier than originally scheduled in order to avoid extreme atmospheric static which builds up in the morning and reaches a maximum at 2:00 p.m. The V-2 carried specially constructed instruments designed to record properties of the upper stratosphere and to provide data on the reflection and refraction of radio waves in the ionosphere at an altitude of about 60 miles.

ASSOCIATION AFFAIRS

Membership Contest

ASA, just approaching the 6,000 mark in memberships, is calling on all members to redouble their efforts in helping gain the objective of 10,000 members by the end of the first year of the Association's existence (May 1, 1947). The last issue of SIGNALS announced a contest: here are the details.

All members of ASA who get new members through their own personal effort will be scored as follows:

25 points for a group member
12 points for a life member
1 point for a full member
½ point for a student member

Scores will be kept at National Headquarters so be certain to give yourself credit when sending in applications. At the conclusion of the contest on May 1st, the grand winner will receive a life membership, a specially designed emblem, a certificate of merit and will be amply spotlighted in SIGNALS; also, if that individual's points total more than fifty, he will receive a cash award of $15.00. The second prize winner will receive a $10.00 credit in books of his own selection and in addition will be given a certificate of merit and publicity in this magazine. Third place will be awarded $5.00 in books, a certificate and publicity.

In the future, it is hoped and anticipated that prizes such as paper weights bearing the seal of the Association, special desk ornaments and emblems will be awarded on this same point system—being available as a member gains enough points to "purchase" the item.

We want to keep a running account of the standing of all individuals who are bringing in new members and future issues of SIGNALS will give their standing. Scores for the local chapter's increases in membership will also be published. JOIN THE COMPETITION! We want and need *everyone's* cooperation and work! Remember—this is YOUR ASSOCIATION.

Army-Industry Communications Day

Inaugurating an annual event of the future, the first Army-Industry Communications Day will be celebrated by Army Signal Association at Fort Monmouth, New Jersey on 29 April 1947, preceded by a banquet in New York City on the evening of 28 April. The proposed speaker at this banquet is to be the Secretary of War.

Chapter News

THE SACRAMENTO CHAPTER has been formed under the able guidance of Col. A. M. Shearer, Signal Officer of the Sacramento Signal Depot. Col. Shearer is serving as interim President and the other officers are: Lt. Col. E. L. Littell, 1st Vice President; Mark Hall, 2nd Vice President; Henry Wild, Secretary; Frank Muench, Treasurer; and Paul Grabish, Assistant Secretary. Here's good luck to this newest chapter of ASA.

Colonel John L. Leidenheimer of the Decatur Signal Depot has been doing a splendid job in securing new members and forming a DECATUR CHAPTER. On 17 December they held a meeting to interest prospective members and their petition for chapter charter should be processed in the next few weeks.

Out in CLEVELAND, Colonel Lee J. Shaffer is getting the ball rolling in a big way in his membership drive. There is to be a dinner on 16 January and shortly thereafter, still another local chapter will be born.

James B. Montgomery, a former captain in the Signal Corps has written National Headquarters offering his services in starting the DETROIT CHAPTER.

It is likely that John J. Ott, Jr., one of our Directors, and Mr. C. R. Maduell of the Delta Electronic Equipment Co., will be instrumental in forming the NEW ORLEANS CHAPTER. Col. Robert Disney of the Bell Telephone Co. of Pennsylvania is in charge of the PITTSBURGH CHAPTER. The RICHMOND CHAPTER has Mr. Arthur L. Lambdin of the Virginia Telephone Co. as its head and Captain Harry E. Fisher, Secretary of the WASHINGTON CHAPTER is planning to go down as representative of National Headquarters to help in the membership drive. The ATLANTA CHAPTER is planning to incorporate the students at Georgia Tech and have only one large and influential chapter. Colonel Thomas H. Maddocks who is Signal Officer of the Seventh Army has been doing a fine job getting this chapter started and has been most cooperative about helping us with our membership drive in his Army area. Colonel Harold W. Dutcher of the Holabird Signal Depot is getting things all set for the BALTIMORE CHAPTER.

Write to National Headquarters for full information about the possibilities of a chapter in your city.

Student Chapters

Captain Harold N. Whitfield, Assistant Professor of Military Science and Tactics of the Signal Corps ROTC Unit at Oklahoma A & M, is to be commended for the interest and initiative he has displayed with regard to promoting interest in the Army. Captain Whitfield is presently engaged in organizing the first chapter of the Army Signal Association of any ROTC Unit in the country. It is this type of "esprit de corps" that is needed for a homogeneous organization within the Army. Other college Signal Corps ROTC units are picking up the tempo set at Oklahoma A & M. Major John M. Goodman of Texas Technological College has written that interest runs high there and backed this up by sending in many applications from his students. At the University of California, Lt. Col. Matthew C. Mautz is going right along with his plans for an effective student chapter.

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Letters to the Editor

Sir:

"I believe the people as a whole and even individuals in the Association are ignorant of the problems confronting the services. Still, the services, in a democracy which usually does not support a large standing army, find it necessary to call upon these same individuals to serve in times of emergency. The Association itself is an educational body. However, this seems to me largely a process done through bulletins and the Association's magazine. I should like to suggest that the Association interest the Army in more formal and intensive training of some of the people in the Association both for the purpose of understanding and communicating to others, as well as preparation for future service, if needed.

"I know that the Army has made surveys in the past for the purpose of determining the possibilities of various producing organizations in case of non-peacetime needs. It seemed to me, however, that industry itself was not aware of its possible position in case of emergency. If these surveys are made, would it be possible, through the Association acting as a liaison between the services and industry, to acquaint industries, companies and plants within companies with the expected requirements which would be placed upon them, whether they come in a prime classification, or whether they are alternates in the plan of industrial mobilization.

"In case of future world disorders in which we might have to participate, the question of time, or rather the lack of time, has been stressed by many people. Is it not, therefore, imperative that we should have some assignments and a knowledge of how we should carry these out, in a program coordinated with others who similarly have been assigned problems? Without this, I question whether there can be enough understanding of the necessity for preparedness, and without the understanding I question whether there would be a ready acceptance of the responsibilities."

Vice President
ASA Group Member

Comment on above from Chief, Procurement and Distribution Service, OCSigO:

1. "I am in full accord with the desirability of educating industry in their part in the proposed Industrial Mobilization Plan. The Industrial Mobilization Branch has been making plans for several of its experienced personnel to contact industry, at the plant level, to make surveys and "acquaint the individual companies with the expected requirements which would be placed on them.

"This action, however, has been held in abeyance pending the formulation of over-all Industrial Mobilization Plans by ANMB and the subsequent authorization to make formal plant surveys. To date, such personal contact has been forbidden by instructions from Army-Navy Munitions Board and Service, Supply and Procurement Division, WDGS. However, the determination of facilities to meet requirements, and the allocation of individual plants to the technical services, is now in process, and it is anticipated that permission to make surveys will be granted in the very near future. The Industrial Mobilization Branch will then put its aforementioned plans into action, and the selected personnel will contact plants allocated to the Signal Corps in the manner indicated in your paragraph 2."

Sir:

I received SIGNAL BULLETIN No. 4 a few days ago. I, being an ex-GI, was especially interested in your discussions of the good and bad military leaders. I consider myself on the middle of the fence because I have seen and worked with both kinds. I have a keen respect for the majority of these high ranking officers I have come in contact with. I find that in most cases a little bit of serious thinking about their duties and responsibilities brings to light the reasons for their actions and judgments which many dissenting soldiers are prone to dub as "Chicken." There must be some bad military leaders, but it is my opinion that those are few and far between.

Homer E. Clark, Jr.

Sir:

In behalf of Press Wireless and myself I wish to congratulate the Army Signal Association upon its splendid publication "Signals." The great importance of communications in both military and civilian operations has long been in need of an organization and a publication such as provided by the Army Signal Association.

We feel that "Signals" can be of greater service to the membership by including departments in which the content is devoted to news and features relating to the various parts of the communications industry. I assure you we will be frequent contributors to such a department.

I feel sure that the Army Signal Association stands squarely behind the entire communications industry and that great mutual benefits will be derived from this close association and interchange of ideas between the Army and the communications industry.

A. Warren Norton
Pres., Press Wireless, Inc.

Sir:

During these days when the vast majority of Americans feel we should maintain an Army of high standards—at least until the UN proves itself capable of successfully implementing the principles for which it stands—I feel it is appropriate to say a word or two in defense of the Army which seems to be the target for destructive criticism of every conceivable nature from columnists, editorialists, news commentators, and the public in general.

I wonder how many of the respected critics give just a bit of thought to the fact that the Army had a strength of approximately 250,000—one quarter of a million in 1941, but three years later had reached close to 10,000,000. Can any commercial industry in the world's history over any period of time compare with an undertaking of this nature?

Then too the problem of demobilization deserves a thought. In 1945 with a strength of approximately 9,000,000 the war came to its end and a year later the strength of the Army had been reduced to less than 2,000,000. This was a task of no small magnitude and the Army was admittedly far from an efficient machine during the major portion of 1946 as a result, but the Army had complied with the dictates of the people which is as it should be in a democracy. A point which should be considered in this connection is the fact that the individual's desire was the governing factor during this demobilization. Thus, the Army was forced to permit the separation of any individual who so desired and understandably lost the service of many key men, many of whom had to be replaced by less efficient personnel.

I have mentioned only two factors in this epistle which, I believe, more than excuse much of the adverse criticism aimed at the Army today.

Today the Army is improving the quality of its personnel by the discharge of the ill fitted, plans are underway which will enable only the qualified to retain their grade or rank, and educational programs are being implemented for the benefit of all. However, these things take time and no thinking person expects them to be accomplished over night.

Thus, I feel that it would only be fair for the reasonable parties who take it upon themselves to comment upon the conduct of the Army to advance in equal portions constructive as well as destructive criticism. Such an attitude would encourage the desirable elements of our young manhood to seriously consider a career in the United States Army which in turn would benefit the Army, the individual, and the nation as a whole. In turn enlistments would be increased and the necessity for a draft law to maintain an adequate Army would soon disappear.

Bruce E. Holmgrain
Major, Signal Corps

Sir:

Your interesting letter of November 21, 1946, has provided us with real food for thought. Our feeling is that the Army Signal Association is a live organization which is filling a very definite need in this country. It would be most unfortunate if the splendid liaison and cooperation that existed between the Army and Industry during the war period did not continue on during peace.

It is our feeling that continued contact between the two groups is necessary in order to keep industry conscious of the need for national preparedness. A good start along this line was the recent dinner meeting held here in Philadelphia and it is assumed that future conferences will be held which will give the Army an opportunity to tell industry of their plans and what they are looking for industry to do.

Vice Pres. and Gen. Mgr.
ASA Group Member

"The United States must forever stand in the forefront of those that strive for the common objective—nothing must deter us from advancing the day when mutual respect will replace mutual prejudice in international relations; when mutual confidence will replace mutual fear. When that day comes the soldiers' task will be completed. Until that day, his readiness to discharge his obligations to the Nation is a matter of deepest concern to all of us."—General of the Army Dwight D. Eisenhower.

BOOK SECTION

CIRCUIT ANALYSIS BY LABORATORY METHODS,

by Carl E. Skroder and M. Stanley Helm. Prentice Hall, Inc. $5.35

The authors state that "This book has been written with the thought that it will be used as a guide and as a text in conjunction with a laboratory course in electrical circuits. Accordingly, it is assumed that the student is taking a theory course in d-c and a-c circuits concurrently with the laboratory course or has already completed such a course." The first two chapters contain suggestions relative to general laboratory procedure and preparation of reports relating to the experiments conducted. Through the remainder of the book each chapter contains considerable descriptive material, with illustrations, leading up to laboratory experiments prepared somewhat in the form of a problem. The number of experiments to be conducted vary from one to a maximum of four on any one chapter, totalling 36 for the entire book.

The material covered ranges from a chapter on fuses and circuit breakers to measurement of polyphase power, with discussions on Kirchoff's laws, series and parallel resonance, etc.

The authors state that they have attempted "to make available a single volume . . . so that the student will have a ready source of information to which he can refer when preparing plans for the laboratory work and when analyzing the data and results." For the experiments (laboratory problems) presented, this aim of the authors has been realized.

THE STRANGE ALLIANCE,

by John R. Deane, 344 pages. The Viking Press. $3.75

In a period in which writers whose only contact with the Soviet Union is through the medium of Rand McNally's maps, are pouring forth book after book on that enigmatic country, it is refreshing, to say the least, to read one written by an author who spent considerable time in wartime Russia. General Deane, former head of the now defunct U. S. Military Mission in Moscow from 1943-1945, tries to describe objectively the negotiations, compromises, deadlocks and achievements of Russo-American cooperation on the military level during World War II. General Marshall's directive creating the Mission to supplant the unworkable attache system stated that its objective was "to promote the closest possible co-ordination of the military efforts of the United States and the U. S. S. R." General Deane learned early in his new assignment that such coordination was to be achieved, if at all, only with superhuman patience, diplomacy and tact, all of which he seems to have possessed to a remarkable degree.

Through his efforts, shuttle bombing became a reality, land and air operations of the allied forces were more efficiently synchronized, repatriation of American internees and prisoners was facilitated, and Russia was prodded into the Japanese war. Of interest to communication specialists is General Deane's account of his attempts to establish an American radio station at Moscow for the improvement of the existing inadequate commercial radio telegraph facilities between the two countries.

General Deane traces the fluctuating progress of the Mission from its early rose-colored expectations of immediate success in 1943 to its pragmatic acceptance of its difficult—and frequently well nigh impossible—task during the last two years of the war. He concludes with a personal appraisal of the Soviet leaders, the Russian people and the current tide of Russo-American relations. His closing words reaffirm his conviction that the United States can and must get along with Russia by meeting her on equal terms of realism and toughness, with a strict adherence to the United Nations Charter.

U. S. CAMERA ANNUAL—1947,

392 pages, 100,000 word text, 340 news pictures and 108 Gallery photographs. U. S. Camera Publishing Corp. $5.75

U. S. CAMERA—1947 is unique in that it is actually two books in one. It represents a 12-year policy of presenting fine photography, beautifully reproduced. This year, the first peacetime ANNUAL since 1941, represents a combination of the documentary type of photo news reporting and fine photography, presented for its own sake.

Volume I is a photographic chronology of the year's news events, both at home and abroad. Some 300 news photos, with approximately 100,000 words of carefully researched text, give a photographic and documentary report of this troubled, chaotic, first year of peace.

Volume II is once again U. S. Camera's prewar gallery of fine photographs. Again, as in the years before the war, Edward Steichen and Tom Maloney have selected a gallery of the year's greatest pictorial prints: human interest photos, classic nudes, portraits, industrials, seascapes—for the lovers of fine photography. Ace photographers—Margaret Bourke-White, Ansel Adams, Will Connell, Eugene Smith, Val Sarra, Bradford Washburn, Aaron Siskind and a host of others are represented, as well as a fine crop of war-produced young photographers. And, as in previous years, there will be but one printing, one edition of U. S. CAMERA ANNUAL—1947.

TOGETHER,

by Katherine Tupper Marshall. Tupper and Love, Inc. $3.50

Mrs. Marshall calls "Together" the annals of an Army wife. It is more than that for she pictures an intimate and close relationship with a great and famous soldier—following his distinguished Army career since their marriage in 1930. One feels the stature and

greatness of General Marshall throughout the book—his calm wisdom and tact—his fine integrity of character. The telling is simple and personal—the subject inspiring and thrilling. It follows through the tense war years when General Marshall was Chief of Staff until he left the United States to become special envoy to China.

Mrs. Marshall tells many interesting stories of their life together as she accompanied him from Army post to post. At Fort Benning where he was assistant commandant of the Infantry School she gained her first knowledge of Army life and customs. She tells of her mistakes frankly and gaily and of her husband's efforts to inform her of the many rules and regulations on an Army post, as important for an Army wife to follow as for the officers and enlisted men—almost bewildering to a newcomer.

From Fort Benning they went on to duty with the C.C.C., the Illinois National Guard and duty with troops in the Northwest and then back to Washington to head the important War Plans Division of the General Staff. General Marshall was later made Deputy Chief of Staff and worked diligently to build up the defenses of our country which were so pitifully weak at the time—1939.

In Washington, Mrs. Marshall had to learn new lessons of established customs for official hostesses. She learned quickly and became not only an efficient and gracious hostess and guest, but also a buffer against the many social demands upon her overworked husband, conserving his strength and guarding his health.

On April 27, 1939, General Marshall was named Chief of Staff to succeed General Malin Craig, upon his retirement on August 31. They then moved to Fort Myer, Virginia, where they were to live for five years. The tense war years are covered by descriptions of the General's many trips, his arduous duties as our war time Chief of Staff and the people he met. Mrs. Marshall has included many letters and editorials to give a complete picture of those trying and heartbreaking years which brought to her the tragic loss of her son in battle in Italy. The grimness is often heightened by amusing anecdotes and encounters making one aware of the brighter side of their life together.

This book will be of more than passing interest to those women and men in the armed services who have served during those stirring years. It should also prove of great interest to the general public for it gives a keen insight into the character of General George C. Marshall, just recently appointed our new Secretary of State. D.R.S.

ALL BUT ME AND THEE,

by Brigadier General Elliot D. Cooke. Infantry Journal Press. $2.75

As one who has read many of "Cookie's" short stories and listened to his participation in conferences at the Army War College in pre-war days, I am not surprised that he has been able to present this important study of psycho-neurosis in our war time Army in a manner that is both thoroughly interesting and instructive. Few Americans realize that the high command was plagued by a problem of this nature. During the war it was of course a military secret that so many of our youth were so little prepared mentally or physically to perform this first duty of a citizen to his country that at one time in early 1943 nearly as many men were being discharged from the Army as were being inducted. Some of those who commanded at the larger training centers in this country were familiar, through cases within their command, with this threat that existed to our success in the war. At many of them, efforts were initiated through "mental hygiene clinics" to bring this matter under local control. We did not know of course how extensive the matter was until we read General Cooke's book. Many of the expressions used in the book were heard repeatedly at many camps within the United States. "Gang-plank fever," "Nervous in the service," etc., are all intelligently explained in "ALL BUT ME AND THEE." It seems to me the MP sgt. in North Africa spoke words of wisdom when he said to Ralph "if a man's a crook in Chicago, he's going to be a crook in New York, Cincinnati and in the Army too. In any bunch of people you're going to have a given amount of crooks and weaklings." And again "We pick up a lot of stragglers that the medicos call psycho-neurotics. They never had what it takes to begin with, so they cave in as soon as the going gets tough."

It was at first a surprise to read at the end of the book that General Marshall had asked General Cooke to publish in book form his experiences and findings. It is quite apparent that the Chief of Staff selected these two combat officers to conduct the investigation because he realized there was a menace to the war effort which deserved an analytical study from the point of view of professional officers rather than mental or personnel specialists who had no experience in soldiering. He wanted America to know about this problem too because he recognized in it an even greater threat to victory if we ever again were involved in war. The book is surely an argument for universal military training so that our young men may have the maturing experiences of association with other young Americans, under military conditions away from home. The type who, either through their own volition or because of mental sickness, avoided front line duty and who as the 19 year old Corporal in North Africa said "never get anywhere, are always bitching about everything, don't belong to anything and are just out for themselves" would then be catalogued and earmarked for other assignments rather than discharged and very likely given a pension for life. It was found that 40% of all men drawing pensions for physical disability are NP cases, and by far the great majority of these never got into combat or even aboard a transport! It should be required reading for every personnel officer and every troop commander.

SHS

"It is proper to emphasize, however, that national strength, even in the military sense, is not founded exclusively, or even principally, upon ships and airplanes and guns and soldiers. Rather it is based upon the country's productive capacity, which in turn, and apart from availability of material resources, is shaped by the unified purposes of our people. National solidarity is a requisite for national security."—General of the Army Dwight D. Eisenhower.

NATIONAL GUARD AND R.O.T.C.

Mission

The mission of the Senior Division ROTC is to produce junior officers who have the qualities and attributes essential to their progressive and continued development as officers of the Army of the United States.

Although the Signal Corps ROTC advanced programs have not had sufficient postwar test to determine program merits, the Signal Corps has utilized highly qualified instructor personnel for the specific task of graduating a student who is well versed in every aspect of Signal Corps development. The Signal Corps has been keeping abreast of the modern trends of research and the latest developments have been integrated into the training of Signal Corps ROTC students. At numerous Signal Corps ROTC Units, radio "ham" stations are in operation, and are being operated by licensed students undergoing ROTC training. For training purposes the Signal Corps ROTC Units have been allotted an SCR-399 radio which under ideal conditions can reach half way around the world. Plans are being formulated to establish an Army Amateur Radio net. It is contemplated that eventually all Signal Corps ROTC Units will be members of this net.

As the programs are presently constituted, the Signal Corps ROTC advanced student receives five hours of instruction per week for a period of 32 weeks in the academic year. Variations incident to a different academic year and interruptions due to holidays, etc., will require adjustment; however, 160 hours per year for the advanced courses is regarded by the War Department as the minimum time necessary for completion of the required subjects. Of this total 96 hours are devoted to branch material subjects in the first year advanced programs and 89 hours in the second year advanced Signal Corps ROTC program.

In addition to the above, the Signal Corps ROTC student is permitted to attend Summer Camp, upon satisfactory completion of the first year advanced course, at which time he will receive either six or eight weeks (dependent on pending legislation) of intensive field training. The purpose of this training is to familiarize the student with the latest Signal Corps equipment and to teach him the correct utilization of such equipment under simulated battle conditions so as to attain optimum efficiency in the event of mobilization. As it is not practicable to maintain units of all the many branches at most colleges and universities, provisions have been made whereby students in scientific and technical courses whose services will be needed and who will wish to be commissioned in branches not represented by units on the campus, if otherwise qualified, may attend an ROTC summer camp of the appropriate branch within quota limitations, and be commissioned in that branch.

Provisions have further been made for students who have had previous honorable military service in World War II in either the Army, Navy, Marine Corps or Coast Guard to receive such credit toward advanced standing in the ROTC within the limits of the following: 12 months or more service credit not to exceed the entire elementary course of the Senior Division ROTC; six months or more service credit not to exceed the first year of the elementary course of the Senior Division ROTC; less than six months service, no credit.

At the present time, the Signal Corps has ROTC units distributed over 23 states—from Maine to California and from Washington to Georgia. It is contemplated that additional units will be activated in the near future depending on existing requirements.

"Zebra," a new launching device for catapult airplanes and pilotless missiles, was recently demonstrated by the Navy. Aviation engineers claim that it is potentially capable of launching large commercial airliners from city rooftops, as well as big bombing planes from short runways.

Annual ROTC Award

ASA's President, Brig. Gen. David Sarnoff announces that there will be awarded annually to the outstanding student in *each* Signal Corps ROTC senior unit with more than 100 students enrolled in the elementary and advanced courses, an ASA merit award. A board, to be appointed by the PMS&T at each college will determine the basis for the award at that college. The prize will be one year's honorary membership in ASA, and a special medal. Generally, it will reward the student who excels in:

1. Demonstrated leadership qualifications.
2. Demonstrating the highest standard of devotion to the three words so descriptive of basic qualities essential in every military leader—"duty," "country," and "honor."
3. Military bearing.
4. Academic ratings in military subjects.

Radar at Washington

Personnel of AWUTC at Drew Field, who were on duty at the radar station at Tarpon Springs, will be interested to learn of a press report that a powerful radar scanning set is being installed at Washington airport by the Air Forces to bring into focus for civilians as well as military controllers the whole air traffic picture for more than 100 miles. Work is well along on the microwave early warning (MEW) system, a tower being constructed on a hill west of the airport to mount the radar scanning apparatus, which has a range of 200 miles under favorable conditions. The MEW system will show the altitude, distance, direction and height of all planes in line of sight up to 100 to 125 miles, it was stated. Scopes showing this information will be assigned to CAA operators, Army operators and Weather Bureau experts.

Correction

In the article "Electronics In the Air Force," in November-December SIGNALS, a photograph of a C-54 making a blind approach was erroneously captioned. The equipment was not GCA, as indicated but a runway localizer which operates in conjunction with the glide path transmitter to comprise the SCS-51 instrument approach system.

SCIENTIFIC DEVELOPMENTS

Tropicalization

The surrender of Japan did not signify a truce for Signal Corps laboratories in their battle to protect communications equipment against persistent enemies in tropical climates and in frigid northern areas.

Spurred by a sharp recollection of hard-won victories over cold and moisture and fungus during the war, engineers are continuing their efforts to improve designs and techniques and to develop equipment even more impervious to destructive agents.

The fight against adverse climatic conditions began early in the war when reports from the field—especially from the South Pacific—told that the functioning of essential radio and other equipment was often being seriously impaired through excessive humidity, fungus growth, insects or inevitably rough handling by landing nets or on the beaches.

The problem of developing protective measures at once became a major concern and the Signal Corps, with the full cooperation of interested industries, speedily evolved an effective program which not only fulfilled the most pressing emergency requirements, but proved adequate in meeting subsequent demands. This program included immediate development of an insulating material that would resist deterioration, certain modifications in design and the adoption of hermetically sealed components.

Since the process of introducing modifications in production necessarily involved some delay, a protective lacquer varnish was devised which was applied to vulnerable components in the field and substantially increased the life and effectiveness of the equipment. This varnish proved to be a reliable fungicide and had a low moisture transition rate.

An invisible fluorescent dye was developed and mixed with the lacquers. This, when used in conjunction with a special lamp facilitated inspection of treated equipment.

All the lacquers were virtually colorless in order that identification marks or numbers on various instruments could be plainly read through them. Thus it was not easy to check on the thoroughness or evenness of the sprayed lacquer.

The special lamp, strong in its emission of ultra-violet rays and equipped with a deep purple filter, picked up the invisible dye in the lacquer and showed clearly any imperfections in the spraying.

From the battlefront the campaign against destructive agents was gradually transferred to the production front and a clause was inserted in Signal Corps contracts which provided for adequate proofing of communications equipment.

While not so widespread as the ravages of the tropics, damage caused by frigid temperatures also demanded new measures of design and a thorough training of communications troops in cold-weather maintenance. Freezing of rotating bearings, gears and other parts was one of the most troublesome problems encountered and the proper handling of lubricating oil, which normally becomes solid at ten degrees below zero, was imperative. To make the oil usable in crank cases it was diluted with 25 per cent gasoline which was sufficient for temperatures as low as minus forty degrees and served a double purpose: to make a motor turn over more easily and to produce the viscosity to lubricate the piston and cylinder walls at the start.

Winter protection involved enlargement of knobs and switches so that men wearing heavy gloves could handle them. Among the ingenious devices developed was the rigid heat shroud built to fit over a one-cylinder gasoline engine power generator set. It is a five-sided collapsible box ingeniously devised with three holes, one for an asbestos duct leading from a portable heater to the enclosed power unit, one for an exhaust air hold and one as outlet for power cables.

To avoid the fire hazard of ordinary oil drainage there was a return to "first principles" in the devising of a pump resembling an old-fashioned bicycle pump. This is used to suck out the used oil so that it can not accumulate dangerously beneath the power unit.

An equally important factor in protecting equipment was the system of packaging adopted. The Signal Corps insisted every item be correctly packaged, so that no matter what kind of a drenching it took it still would click into instant operation when it was unpacked and set up on a coral atoll in the Pacific or in a monsoon-lashed port of Burma.

Each dry battery, for instance, was packed in a unit package that was wrapped with a waterproof bag. Several unit packages were then placed in a standard, moistureproof carton, which in turn went into a protective bag made of laminated film, heat-sealed for added safety. Finally the sealed bags, with their contents, were put into a packing case which included a waterproof liner. Even then nothing was left to chance. The entire case was temperature-tested in various climate ranges; it was given two immersion tests, and it was drop-tested for strength.

Shockproofing also was necessary since delicate apparatus was easily injured. For many larger radio tubes a slatted packing case was made. The slats allowed stevedores and others handling the case to see the contents and consequently to take special care. On each of the inside corners were webbed bindings. These bindings were wrapped around the extremities of the tube and made rigid. Or sometimes the tubes were taped around the middle and from this tape went webbings to each corner of the crate. These webbings were made taut and the tube was thus suspended in air, immune to shocks.

"With the development of atomic energy, jet propulsion and guided missiles, we have embarked upon an age in which total war can come literally with a flash of lightning."—Vice Admiral Louis F. Denfeld.

NOTES FROM FORT MONMOUTH

EMS School

Lt. Col. Gorden B. Cauble, Personnel and Administration Officer for the Enlisted Men's School at Ft. Monmouth, has announced that a drastic reduction in the authorized T-O of assigned overhead personnel went into effect on 1 January 1947. Col. Cauble said that the authorized number of enlisted men will be 640, officers 62, and civilians 81. The total assigned strength of enlisted men in the school overhead before this order was only 473, which was very much below the authorized strength. It was explained that although the authorized strength had been lowered, it would actually mean no loss of personnel, but rather a gain of assigned men. The men needed to bring the force up to the authorized number will be taken from the graduated students unless other sources can be found. On 30 November there were 2,414 students in EMS but inputs from training centers all over the country have raised the student strength to approximately 5,200. Each month the honor students from EMS are awarded certificates of merit and given three day passes.

Antarctic Trip

Amory H. Waite, Jr., a civilian engineer at Coles Signal Laboratory left in late November for his second trip to the Antarctic with Admiral Richard E. Byrd. Officially, Mr. Waite is a Signal Corps observer on the expedition and has the distinction of being one of the few civilians in the group of 4,000 to be making the trip. On the last expedition in 1933, Mr. Waite was a radio operator aboard the SS *Bear of Oakland.* For his efforts in rescuing Admiral Byrd and the rigors he suffered during that expedition, Mr. Waite received the Congressional Medal inscribed, "For Achievement Unequaled in Polar Expeditions." The Bronze Star, which is rarely given to a civilian was awarded to Mr. Waite for his heroic work in England and France from May to September 1944. He supervised the installation and operation of a station on the Isle of Wight, and five days after landings in Normandy had established communication with his collaborator in France. For nearly two months this was the only reliable means of voice comunication between the beachhead and England. After returning from the ETO, Mr. Waite proceeded to the Philippine Islands and Japan for installation of radio relay equipment from July to November 1945. He also was in the party of Signal Corps observers who were at Bikini for the Atom Bomb tests.

Officers Training Course

Brig. Gen. Jerry V. Matejka inaugurated the opening of the officers supplementary education and training course in late November at Ft. Monmouth. Lt. Col. I. C. Stoll, O.I.C. of Training, S.C.S., expressed the hope that full cooperation would be given by all officers, and felt that the various sub-courses to be offered would be an extensive help in the review of military essentials. Of the fifteen courses to be covered, such phases as Indoctrination, Methods of Instruction and Training, Procedure, Military Boards and Courts-Martial, Personnel, Management, and Staff Functioning will be presented. Officers now on active duty can take advantage of this program which provides standard courses of instruction. The tri-weekly meetings will be attended by all officers who were commissioned in the Regular Army subsequent to 1940, plus those who wish to take the course for refresher reasons.

Guided Missiles Address

At a meeting of the Fort Monmouth Chapter of ASA, Wilbur C. Brown, radio engineer in the Office of the Director of Engineering, Signal Corps Engineering Laboratories, told of the Signal Corps phase of the guided-missile program which is currently being studied by the Army, Navy, industrial concerns, and university laboratories. Mr. Brown revealed that the radar sets used during World War II will not ever again be a satisfactory defense against guided missiles. The Signal Corps is actively concerned with new methods of warning and detection of these weapons, which includes the location of their launching bases, tracking the missiles in flights, developing electronic countermeasures and probing meteorological conditions in the upper atmosphere. The responsibility for co-ordination of all communication systems to, from and at the White Sands, N. M., area has been given the Signal Corps. A radioteletype system is in operation from White Sands to Coles Signal Laboratory, Red Bank. According to Mr. Brown, there is close cooperation between the Signal Corps and the AAF in the radar-warning aspects of the project. Because of the speeds encountered, all existing methods for projectile flight plotting have proved unsatisfactory.

Visitors to the Post

Brigadier J. P. McLare, Deputy Director of Mechanical Engineering for the British Army, who is now on duty with the War Office of the British Army Staff in Washington, and his assistant, Colonel O. G. Trevethick, were recent visitors at Fort Monmouth. Brig. Gen. Jerry V. Matejka, Commanding General of Fort Monmouth, welcomed the British officers and conducted them on a tour of the Schools and the Engineering Laboratories.

"The industry of America, management and labor alike, gave us a superiority that turned the tide of war. And only these two, working together in the national interest can give us the best guarantee that peace will prevail, and the best assurance that, if in spite of our best efforts war should come, we can again be victorious."—Under Secretary of War Kenneth C. Royall.

The War Department has rejected a plan, proposed by the state of New Jersey, for converting Fort Dix and Camp Kilmer into veterans' housing projects. These installations are still required for Army operations.

Group Members

The communications and photographic industries are proving their faith in Army Signal Association ideals and objectives as more and more of the large manufacturing and operating companies join as group members. The following have become members since the last issue of SIGNALS.

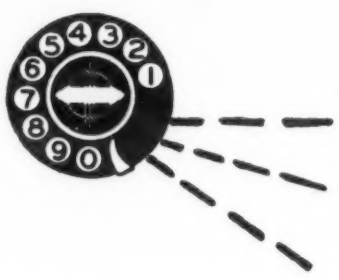
Clarostat Manufacturing Co., Inc.
Collins Radio Co.
Farnsworth Television & Radio Corp.
Illinois Consolidated Telephone Co.
General Telephone Corp.
Packard-Bell Co.
Radio Condenser Co.
Stackpole Carbon Co.
United States Electric Manufacturing Corp.
Victor Bernard Industries.

Life Members

The following individuals have signified their active and abiding interest in the security of the United States by becoming life members of this Association.

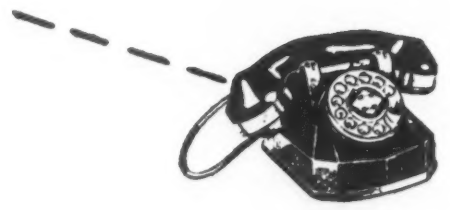
Paul Case Armor
Col. Sosthenes Behn
Lt. (j.g.) Edward J. Behn
Lt. William C. Behn
Major Wayne O. Brewer
Carl D. Brorein
Col. Frank Capra
Lt. Charles E. Clark
Daniel Cole
Major Lawrence J. Corsa
William C. DeVry
Lt. Col. Ernest E. Ferguson
Lt. Col. David P. Gibbs
Maj. Gen. George S. Gibbs (Deceased)
Joseph Gorodiz
Captain Myron J. Green
Captain Laurence W. Hacker
Major Max W. Hall
Francis S. Heath, Jr.
Col. William C. Henry
Lt. Robert C. Herrick
Lt. Charles T. Hibbard
Captain Joseph E. Houk
Dr. Frank B. Jewett
H. Donn Keresey
Col. J. Harry LaBrum
Frederick R. Lack
Captain Elmer S. Lesher
Col. Thomas H. Maddocks
Col. F. W. Moorman
Lt. Thomas Clinton Musgrave
Col. William V. Norton
W. H. Parkin
Major J. B. Prestridge
Col. Van Ness Philip
Marcel C. Reeds
Captain Thomas M. Rienzi
Thomas A. Riviere
Brig. Gen. David Sarnoff
Col. Henry H. Scudder
Lt. Rene C. Smoller
Lt. Col. Andrew D. Stephenson
Lt. Col. Arthur W. Tager
Col. Samuel Robert Todd
Lt. Col. Harold C. Williams
Col. Frank W. Wozencraft
Col. Darryl F. Zanuck

"The United States Army has always been the instrument of national policy —never the maker of it. Army leaders accept it as elementary that the military is subordinate to the civil power. Officers traditionally abstain from partisan politics in order to avoid involvement with the making of policy which they may have to execute. That is sound doctrine and sound practice. The Army's aloofness from politics comes down from its first commander, General Washington, who laid down the rule as first standard of behavior at a time of peril when the civil power was weak and the grievances of the soldiers flagrant. The Army's fidelity to General Washington's rule has never waivered. The Army sees itself in 1946, as in the 1770's, as the servant of the people of the United States, dedicated to doing the people's bidding, whether it be to fight foreign foes, govern enemy areas overseas, relieve the victims of flood or fire at home, or do whatever else the Congress may direct it to do. Strong or weak, praised, or criticized, it has never failed in its duty, and it never will."—Secretary of War Robert P. Patterson.



The Pulse of Modern Business

● You have your finger on the "pulse" of your organization—when you dial the P-A-X telephone on your desk. A few flicks of the dial, and you're in contact with any department. In minutes, you save hours, as you make your rounds by P-A-X telephone. For the farthest corner of the organization is always within arm's reach—literally at your finger tips!



● For further information regarding Automatic Electric P-A-X, please address: Automatic Electric Sales Corporation, 1033 West Van Buren Street, Chicago 7, Ill.

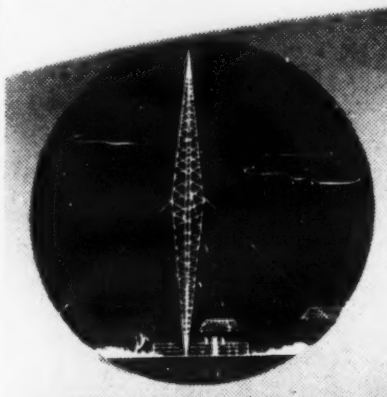
AUTOMATIC ELECTRIC

COMMUNICATION AND SIGNALING EQUIPMENT

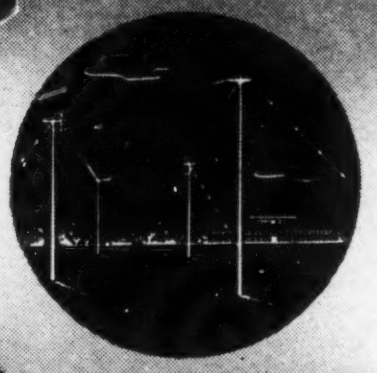
Why THIS TEAM IS *Up* ON ANTENNAS

1920 Loop antenna for 400-500 meter ship-to-shore radio telephone receivers. Its design enabled earliest measurements of field strength.

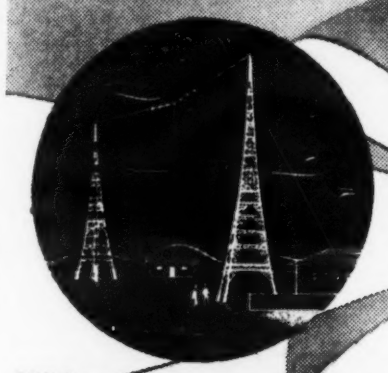
1929 Curtain antennas developed for beaming short-wave radio telephone messages to Europe and South America . . . improved commercial service.



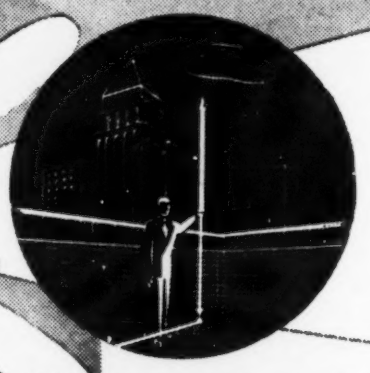
1930 Half-wave vertical radiator, now in general use, was developed into practical form. It greatly improved signal output of broadcast stations.



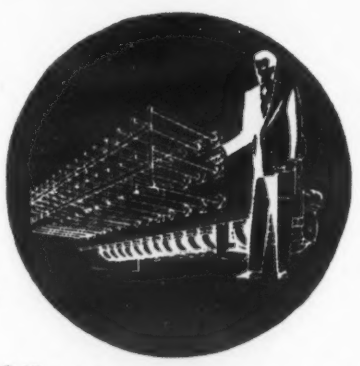
1930 Rhombic (diamond-shaped) antenna for 14-60 meters. It covers wide frequency range without adjustment. Still standard for this band.



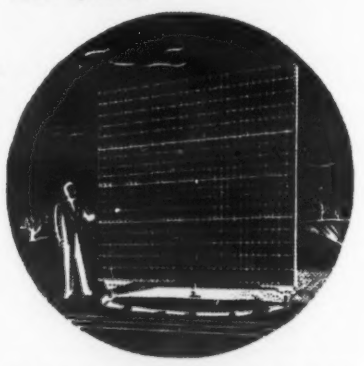
1934 One of the first directional antenna arrays for broadcasting. Designed for WOR to concentrate signals in service area, eliminate radiation over ocean.



1938 Coaxial antenna for ultra high frequency communications, designed by Bell Laboratories, gave increased signal strength. Widely used in police radio systems.



1941 Polyrod radar antenna was an important war contribution . . . helped sink many Jap ships. Its exceptionally narrow beam and rapid scanning gave high accuracy to big Navy guns.



1944 Metal lenses, another Bell Laboratories development, focus microwaves like light. One type has a beam width of only 0.1°—or less than that of a big searchlight.

1947 New 54A Clover-Leaf FM broadcast antenna has high efficiency and a circular azimuth pattern; is simple to install and maintain. May be used for any power level up to and including 50 kw.

As pioneers and leaders in radio, Bell Telephone Laboratories and Western Electric have been vitally concerned with the development of improved antennas for more than 30 years.

From the long-wave days of radio's youth, right through to today with its microwaves, this team has been responsible for much of the progress in antenna design.

Progress based on Research

Following their long-established method of attack, Bell Laboratories scientists are continually *observing*, *investigating* and *measuring* the action of radio waves in space. Their research has covered wave lengths ranging from hundreds of meters to a fraction of a centimeter. In over a quarter century of intensive study, they have learned how radio waves behave, day and night, under all sorts of weather conditions.

Out of this fundamental research have come such outstanding developments as the rhombic antenna, musa antenna, vertical half-wave radiator, curtain antenna, directional array, the polyrod and other improved radar antennas, the metal lens for microwaves and the new Clover-Leaf antenna for FM broadcasting.

What this means to YOU

Whether you are interested in AM or FM—equipment for broadcasting, point-to-point, aviation, mobile or marine use—here's the thing to remember. Every item of radio apparatus designed by Bell Laboratories and made by Western Electric is backed by just such thorough scientific research as has been given to antennas. It's designed right and made right to give you years of high quality, efficient, trouble-free service.

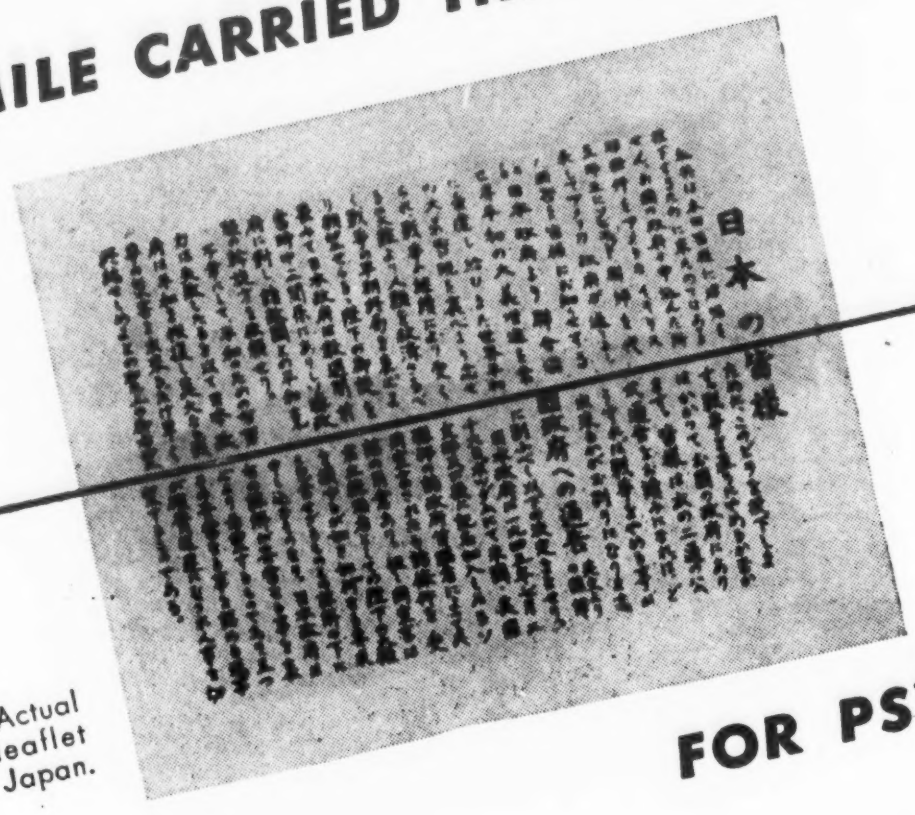
BELL TELEPHONE LABORATORIES

World's largest organization devoted exclusively to research and development in all phases of electrical communications.

Western Electric

Manufacturing unit of the Bell System and the nation's largest producer of communications equipment

FACSIMILE CARRIED THE AMMUNITION



Actual surrender leaflet dropped on Japan.

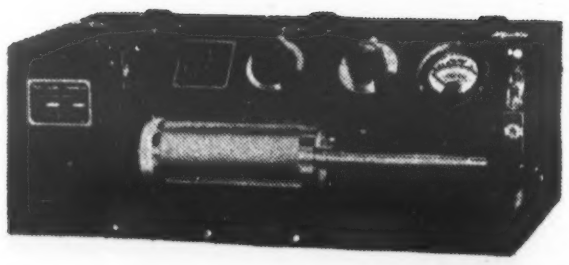
FOR PSYCHOLOGICAL WARFARE!

Times Telephoto transceivers were constantly used as a weapon of Psychological Warfare Units in transmitting pictures and text for shell and airborne leaflet campaigns.

The dramatic climax to facsimile's part in psychological warfare came with the last message dropped on Japan. It informed the Japanese people of their government's agreement to unconditional surrender.

The text for this leaflet was prepared in Washington—telephoned directly to Honolulu, transcribed into Japanese and transmitted by facsimile to the Times Telephoto recorder on Saipan.

In less than 26 hours after the original text was telephoned to Honolulu from Washington, the first flight of B-29's carrying 900,000 surrender leaflets took off from Saipan.



Today, Times Telephoto is actively engaged in applying its war-won knowledge toward the development and production of many types of message and photo-facsimile equipment.

TIMES TELEPHOTO EQUIPMENT, INC.

A Subsidiary Of The New York Times

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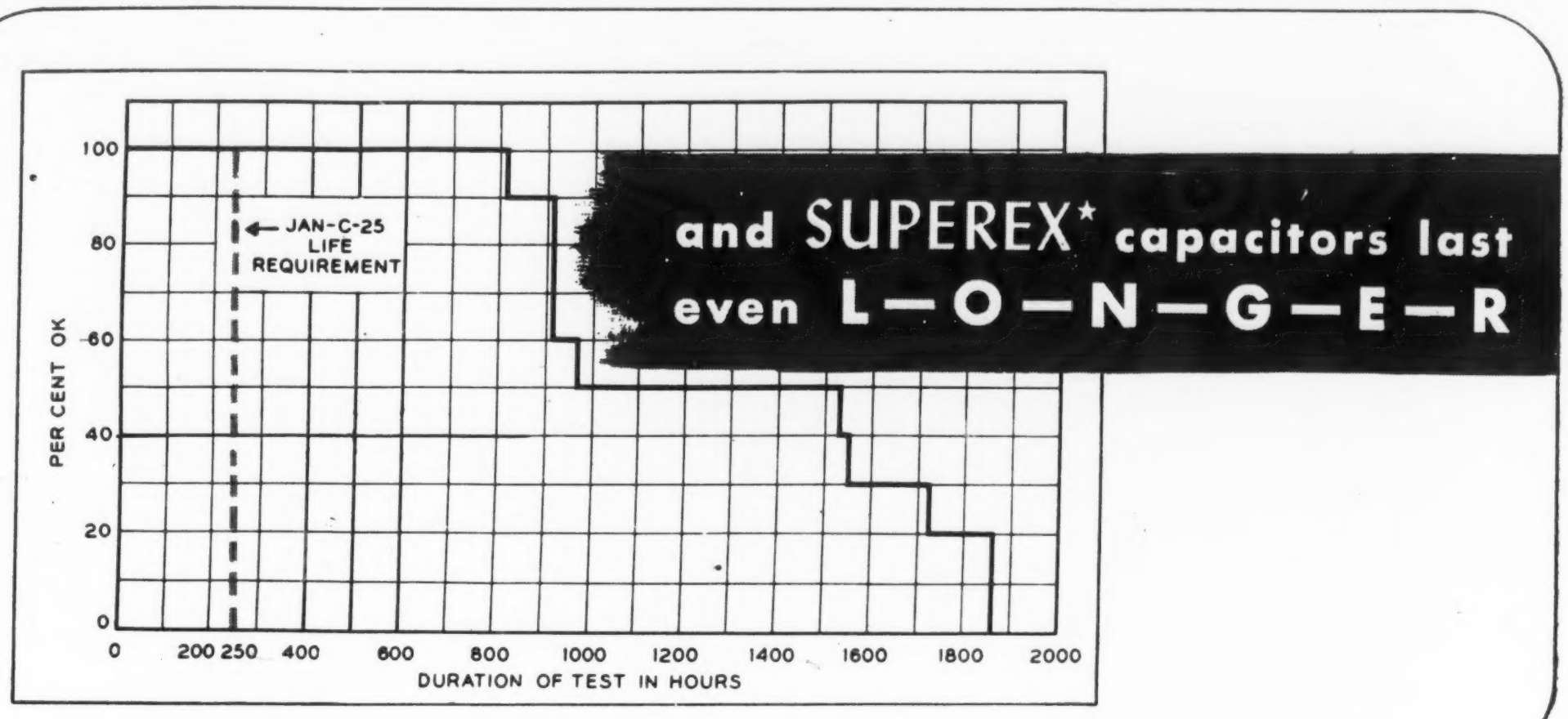
they've got to last L-O-N-G

. . . to meet Joint Army-Navy Specifications



Two-hundred-fifty hours under 1.4 times rated voltage at the high temperature of 85°C is the rigid accelerated life requirement of Joint Army-Navy specification JAN-C-25 for fixed paper capacitors, characteristic F.

A typical group of Solar **SUPEREX*** capacitors—taken at random from commercial production—was placed on a life test under severe conditions. *Not a single failure occurred before 816 hours had elapsed.*

This is not an isolated instance. Repeated tests of **SUPEREX*** capacitors, taken from the commercial production line, show the same outstanding long life.

If you need the utmost in capacitor performance and "Quality Above All", write Solar Manufacturing Corporation, 285 Madison Avenue, New York 17, N. Y.

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"Quality Above All"

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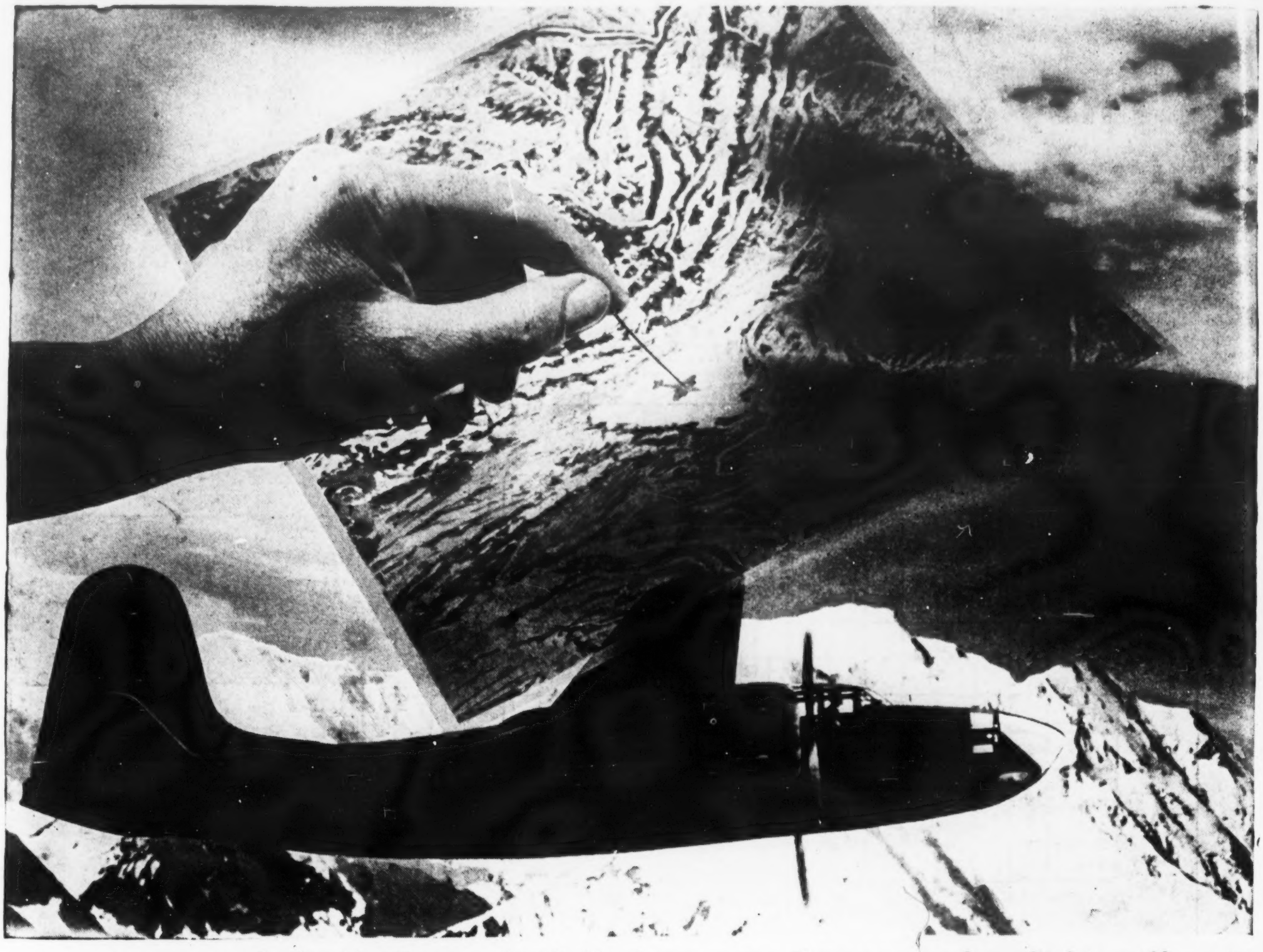


Developed by RCA as an aid to blind bombing in wartime, Shoran is a new radar yardstick for world mapping

SHORAN—a surveying system with pin-point accuracy!

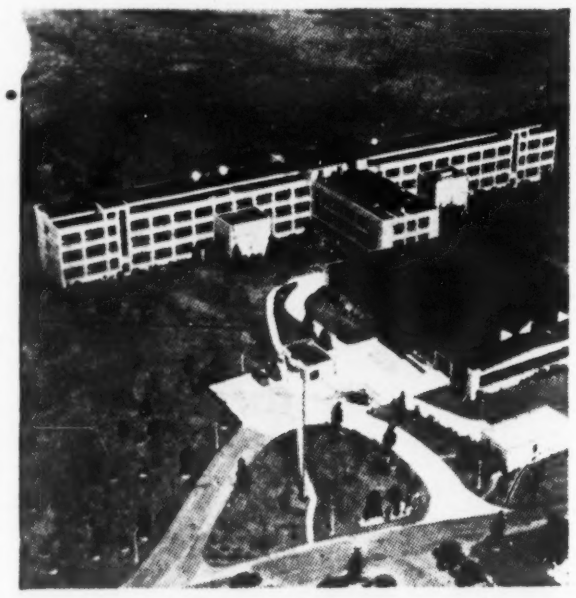
One small error in a map can be costly in the location of an oil well or mining property. But with Shoran, vast areas can now be charted by plane with an error of less than twelve inches in five miles—and in a matter of minutes or hours as opposed to weeks or months that would be required by laborious surveys made on the ground. Shoran is called one of the most important geographic inventions since the compass.

Shoran can also direct a plane flying in a blackout or heavy overcast with such accuracy that during the war it was possible to drop bombs only a few hundred feet ahead of completely invisible advancing troops below with unerring precision.

Just as Shoran is a revolutionary stride forward in map-making, so do all RCA products represent the farthest point of progress in their fields.

And when you buy anything made by RCA or RCA Victor, you are sure of getting one of the finest instruments of its kind science has achieved.

Radio Corporation of America, RCA Building, Radio City, New York 20. Listen to The RCA Victor Show, Sundays, 2:00 P. M., Eastern Standard Time, over NBC Network.



Until recently a closely guarded military secret, Shoran was developed at RCA Laboratories—a world center of radio and electronic research. Here, in this vast community of scientists, the same imagination and skills that developed Shoran keep RCA and RCA Victor the outstanding names in radio, television and recorded entertainment.

RCA **RADIO CORPORATION of AMERICA**

hallicrafters *new Model* S-40

New beauty and perfect ventilation in the perforated steel top

Separate electrical bandspread with inertia flywheel tuning.

Tuning range from 540 kc to 42 Mc continuous in four bands

Self-contained, shock mounted, permanent magnet dynamic speaker

All controls logically grouped for easiest operation. Normal position for broadcast reception marked in red, making possible general use by whole family.

Automatic noise limiter

3-position tone control

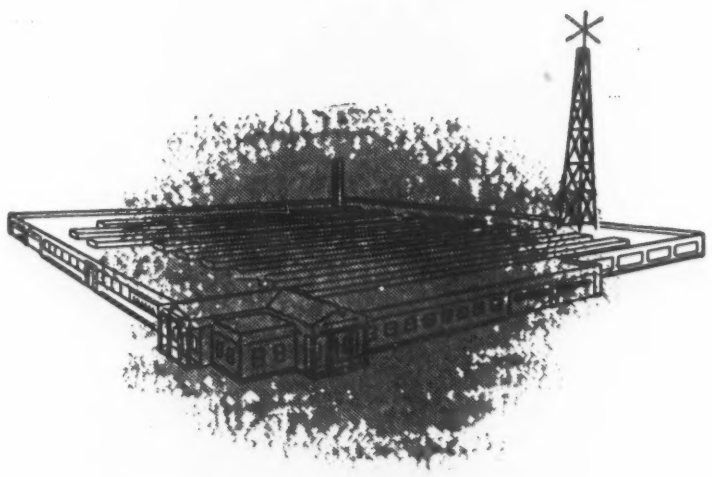
Standby receive switch

Phone jack

New design, new utility in a great new communications receiver . . .

(APPROXIMATELY) **$79.50**

Here is Hallicrafters new Model S-40. With this great communications receiver, handsomely designed, expertly engineered, Hallicrafters points the way to exciting new developments in amateur radio. Read those specifications . . . it's tailor-made for hams. Look at the sheer beauty of the S-40 . . . nothing like it to be seen in the communications field. Listen to the amazing performance . . . excels anything in its price class. See your local distributor about when you can get an S-40.



INSIDE STUFF: Beneath the sleek exterior of the S-40 is a beautifully engineered chassis. One stage of tuned radio frequency amplification, the S-40 uses a type 6SA7 tube as converter mixer for best signal to noise ratio. RF coils are of the permeability adjusted "micro-set" type identical with those used in the most expensive Hallicrafters receivers. The high frequency oscillator is temperature compensated for maximum stability.

From every angle the S-40 is an ideal receiver for all high frequency applications.

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